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THE ENGLISH SPARROW.

(*Passer domesticus.*)

THE following facts are from the *American Naturalist:* Every fact touching the relations of the English sparrow to our native birds should be put upon record, to the end that a just conclusion may be reached in regard to its character. During the present month (June, 1879), Hon. Wm. H. Upson, of Akron, called my attention to the fact that a box erected for birds in his yard had, in the spring, been occupied by the sparrows; that the house-martins had taken forcible possession, driven out the sparrows, and were then occupying the box, which the sparrows were constantly endeavoring to regain. Going to his grounds I found one of the martins sitting as a sentinel at the door of the box, and in a few minutes the sparrow appeared with materials for nest-building in its bill, hanging around apparently waiting for an opportunity to enter the box; it never tried to enter while the martin was sitting in sight at the door, but as soon as the passage seemed clear, made the attempt; it was every time driven away by the martin. I watched the controversy for an hour, during which many attempts were made to gain possession. The sparrow never called for re-enforcements, but twice the martin gave a sharp call which brought several others to his assistance. It was very evident that the martin was able to hold the fort.

Mr. Upson has many trees and much thick shrubbery in his yard, and although his grounds are in the city of Akron, they are filled with a large variety of our native birds, and he reports that they are all fully able to take care of themselves in the presence of the sparrow, but suggests that in large numbers the sparrows may induce a bird famine, and in that way alone tend to diminish the number of our native birds.

Prof. Elizur Wright, of Mass., was the guest of Mr. Upson at the time of my visit, and was much interested in the controversy between the sparrow and the martin. He stated that in his grounds at Medford, near Boston, the sparrows from the city attempted to take possession of boxes erected for the bluebirds and the white-breasted swallow, but were driven away from the boxes and off from the grounds by these native birds. He reported the following birds as frequenting his grounds and a clump of forest adjacent to them: Bluebird, white-breasted swallow, scarlet tanager, wood thrush, summer yellow bird, red start, song sparrow, chipping sparrow, grass finch, cat bird, brown thrush, gold finch, indigo finch, house and wood phœbe, towhee bunting, Baltimore oriole, orchard oriole, white-eyed vireo, red-eyed vireo, fly catchers, king bird, cuckoo, etc. He also states that in his grounds the red squirrel is a great plunderer of the eggs of the birds.

July 8.—The sparrows in Mr. Upson's grounds have finally regained possession of their box. Mr. Upson informs me that they never made a direct attack upon the martins, but watched the box continuously for many weeks, and at every possible opportunity carried nest-building materials into it, until the patience of the martins was exhausted, their associates were called together in consultation, and the box abandoned.—*M. C. Read, Hudson, O.*

I am informed by Mr. John M. Shorten, of Cincinnati, Ohio, of a humming-bird brought to him to be mounted, which had been killed by English sparrows. A friend of Mr. Shorten witnessed the attempts of the pests to destroy the little hummer, but unfortunately did not succeed in rescuing it until life was nearly extinct.—*Elliott Coues, Washington.*

I have recently noticed what seemed to me a curious habit of our English sparrow. On several occasions while walking through the city, I have seen them take potato bugs and other insects when on the wing, after the fashion of swallows.

I have also repeatedly noticed those sparrows climbing tree trunks in spirals exactly like a creeper, stopping at intervals to pick up insects and the nests of our common yellow caterpillar from the interstices of the bark. Sometimes the bird would flutter to the ground and reascend, sometimes go from the ground to the lower branches, and then try another tree.—*J. R. Taylor, M.D.*

THE phylloxera has destroyed about one-fifth of the vines planted throughout France, and the loss to the State is estimated at three milliards. M. Leonce Guiraud, of the Nîme Chamber of Commerce, recommends the cultivation of American vine-stocks on all poor land, as they, though not yielding the quantity or quality of the old vines, have as yet resisted the disease very well.

THE GORGON GNU.

THE illustration herewith given represents a recent interesting acquisition made by the Jardin des Plantes at Paris—a specimen of the Brindled or Gorgon Gnu (*Catoblepas gorgon*). The gnu is one of the most singular of animals, having the head and horns of a buffalo, the body and mane of a horse, and the limbs of an antelope. The form of the head, neck, and shoulders is decidedly bovine, robust, and clumsy; the forehead wide and flat, the muzzle broad, and covered with hair except the valvular opening of the nostrils; the eyes large; ears long, narrow, and pointed; horns present in both sexes, above and behind the eyes, close together at their origin, descending downward and outward, then curving upward and backward, flattened at the base, cylindrical at the tip, rough, and irregular. The hair on the brow and forehead is long and shaggy, giving a fierce expression to the face. The neck has a rigid mane above and a long, hairy dewlap below. The shoulders are deep and surmounted by a moderate hump. The body is rounded like that of a horse, and the limbs delicately formed. The tail is moderately long, with a brush at the end; the hair elsewhere on the body is short. The hoofs are rather large for the limbs, and the skin of the knees is bare and callous from their habit of going on their knees in attack and defense. The animal, though clumsy in appearance, is very swift and active, galloping over the plains like a horse, and feeding in large herds like wild cattle. When alarmed it rarely takes to flight until it has examined into the cause of the danger—a curiosity of which the hunter is able to take advantage. It is very pugnacious and is tamed with difficulty. The Gorgon gnu is larger than the common species, and measures about 5 ft. at the shoulders and 7½ ft. from nose to tail, the tail being 1¾ ft., and the horns about 2 ft. long. The face is blackish, the sides of the head and neck yellowish gray, the latter and the shoulders with vertical dark stripes, the body above and the sides glossy, reddish gray; below, and the limbs, reddish brown. It inhabits the extensive grassy plains of Central Africa, advancing southward after the summer rains to the Orange River, south of which only the common species (*C. gnu*) ranges. Great numbers are killed every year by the Cape colonists, and their flesh is considered excellent as food.

THE GORGON GNU.

THE TIGER AT BAY.—BY G. B. GODDARD.

THE TIGER AT BAY.

THE spirited drawing of *Felis tigris*, which we give opposite, is by the well-known English artist, Mr. G. B. Goddard, and for it we are indebted to a recent number of the *Illustrated London News*. Tigers are still numerous in India, where they are greatly dreaded by the inhabitants, and not without reason. Last year (1878), according to official reports, large numbers of cattle of great value, together with upwards of twenty thousand people, were killed in India by poisonous reptiles and wild beasts, foremost in the destruction being the ferocious animal depicted in our drawing. The British Government pays a handsome reward for every one of them that is killed, and the skins also bring high prices. Tiger hunting in India is thus an endowed and active institution; but the extinction of the beasts makes rather slow progress.

The tiger is the largest, strongest, and most active of the cat family. Its face, front, and under parts are nearly white; the ground color, bright orange yellow, the whole body being striped with black bands and bars, presenting a magnificent appearance. It leaps to a great distance upon its prey, makes but little noise, prowls in the night time, and sleeps in shady places in the day. The animal averages 3 to 4 ft. in height and 8 ft. in length.

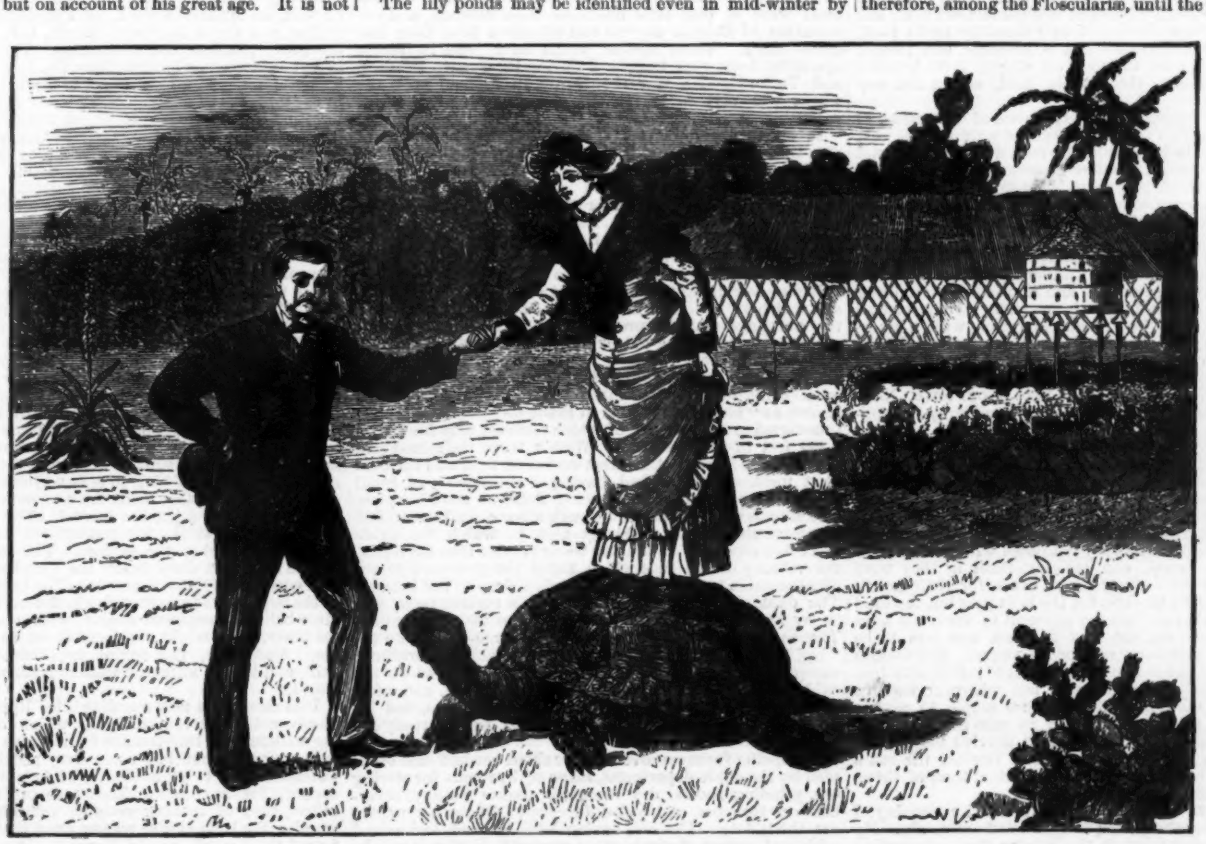
THE SEA SERPENT.

THE last appearance of the sea serpent was on the French coast. Captain J. F. Cox, master of the British ship Privateer, which arrived at Delaware Breakwater on the 9th instant from London, says: "On the 5th ultimo, 100 miles west of Brest (France), weather fine and clear, at 5 P.M., as I was walking the quarter-deck looking to windward, I saw something black rise out of the water about twenty feet, in shape like an immense snake, about three feet in diameter. It was about 300 yards from the ship coming toward us. It turned its head partly from us, and went down with a great splash, after staying up above five seconds, but rose again three times, at intervals of ten seconds, until it had turned completely from us and was going from us with great speed and making the water boil all round it. I could see its eyes and shape perfectly. It was like a great eel or snake, but as black as coal tar, and appeared to be making great exertions to get away from the ship. I have seen many kinds of fish in five different oceans, but was never favored with a sight of the great sea snake before."

A TORTOISE 150 YEARS OLD.

THIS is the property of a gentleman resident near Colombo, Ceylon, and it is remarkable not only because of his great size and docility, but on account of his great age. It is not known when he was brought to Ceylon, but it is generally believed that he was sent from Mauritius to Batavia, and thence forwarded to Ceylon as a gift to one of the Dutch governors many years ago, and that he is now more than 150 years of age. When the Duke of Edinburgh visited Ceylon in 1870, a collection of curiosities was made for his inspection in Colombo, and this tortoise was with difficulty conveyed in a cart to the show, where he received a silver medal, but on his return home he scrambled out of the cart and sustained considerable injuries by the fall. It was therefore decided that he should never be sent from home again, and since that date visitors to Colombo, amongst whom has been the Prince of Wales, have had to drive out of town to see him in his own domain.

A few years ago he could walk about with three persons on his back, but he is now blind and less active than he once was, although he still moves about a good deal in search of food, etc. He lives upon grass, and in the dry season, when the grass in the park is withered up, and the pools of water which he frequents are dry, he comes to the kitchen, where the servants keep a bundle of green grass and a bucket of water in readiness for him. Although he is blind it is remarkable how he finds his way about without coming to grief. His length from nose to tail is 5 feet 3 inches; height, when standing 2 feet 3 inches; and weight about 2¼ cwt; while the shell is 4 feet 7 inches long, and 4 feet 3 inches in breadth.—Our engraving is from a sketch by Mr. W. H. G. Duncan, Colombo.—*London Graphic.*



A TORTOISE 150 YEARS OLD.

SUMMER WALKS AFTER UNSEEN THINGS.

(Proceedings of the Academy of Natural Sciences, Philadelphia.—Biological and Microscopical Sections, October 20th, 1879.)

Director Dr. R. S. KENDERDINE in the Chair.

Dr. J. GIBBONS HUNT read a paper on

"SUMMER WALKS AFTER UNSEEN THINGS."

He proposes in a simple way to offer some results, gleaned during walks after unseen things through the past brief but beautiful summer.

He will not go into our ornamental City Park, but far away into the forest solitudes of New Jersey, where talking men are seldom met; among the sandy bogs, or on those sweet, *brown-water* lakes, fringed often with the evergreen and ever murmuring pines, into the "Pine Barrens" of New Jersey.

On the upper branches of Maurice and of Great Egg Harbor rivers, are many ponds; some are shallow and covered with aquatic plants; others are large and deep and navigable for small vessels. They are fruitful hunting places for unseen things.

It is possible to judge of the comparative ages of these ponds by the microscopic life found in them. The older the pond, the richer and greater the variety of animal and vegetable forms.

He has found in abundance in the *old* ponds, fresh water sponges, green as growing grass, incrusting submerged branches and plants, and having ramifications as long as the fingers. The attention of the members was called to the American *Spongilla*. They are not surely determined, and require great skill to make out their structure. Their abundant spicules—the endo-skeleton—remind us of the raphides in some plants, and are the earliest foreshadows of the skeleton in higher animals. The green chlorophyl gives to it color, and it is not rare to see this vegetable paint adorning also the animal organization. We have green hydra, green stentors, green euglena, and many other low animal forms of the same color. He has found in these ponds a green vorticellina not found in the books, in all of whose tissues chlorophyl is revealed by the micro-spectroscope. The chlorophyl granule is the physiological analogue of the red blood corpuscle, and in our ignorance of animal and vegetable life there is no reason why one should not supplant the other in the *lower* organizations.

The lily ponds may be identified even in mid-winter by the innumerable curious and hard branching cells found in the mud, which come from the lilies after their softer tissues decay. The brown water in sheltered coves is sometimes completely carpeted with the water shield, *Brasenia peltata*. The upper surface of the leaf is deep green, and covered with stomata. All submerged parts are purple, and that color arises in faintest line all around the upper margin of the leaf. As a general rule, floating leaves have stomata only on the upper side of the leaf. This plant is an exception. On the under side and near the margin of the leaf the veins arch outward, and return in straight lines. As a keystone to each venous arch there is a minute cluster of stomata, varying in number from five to thirty. They occupy also the tops of minute depressions in the under surface of the leaf, and it is probable, as the plant rocks on the wind-stirred water, that a small bubble of air occupies these depressions, and comes thus in contact with the submerged stomata.

It is not unusual for many vegetable structures to clothe themselves in jelly.

Some fungi do so. The simplest types of algæ draw around the perishable organizations a thickened cellulose or gelatinous envelope, as if to carry their perishable lives over periods of drought and desiccation. In previous lectures he had mentioned cases, but in not one is there found special organs to excrete that jelly.

In *Brasenia* there are special jelly glands covering all submerged parts of the plant. They are not mentioned in the books anywhere. They are cylindrical in form, are about 180th of an inch in length, growing out from and connected with special epidermal cells of oval form, which differ in contents and formation from the ordinary contiguous cells. These cells are filled with a dense and nearly transparent protoplasm, which throws out the jelly, apparently through the thin walls of the glands.

The jelly from one gland touches and unites with that next it until the entire submerged parts become encased in a gelatinous garment.

If we would behold unusual sights, we must look into unusual places.

Nests of strange water creatures, eggs of diptera and of other insects, are abundant in such places, though partially concealed in thick forests of cryptogamic vegetation.

Among all these usually unseen things we pick out minute globular masses of clear jelly adhering to some leaves. Under a good microscope, properly illuminated, these jelly drops reveal visions of beauty in animal organization, probably never before seen by human eye. There is no record of them in the books. Each drop of jelly measures about the one-twentieth of an inch in diameter, and contains from three or four up to thirty transparent ciliated animals, all radiating from a central place of attachment in the drop towards the circumference, like spokes from the hub of a wheel. These animals are exceedingly contractile and sensitive, and capable of surprising extension. When fully out and feeding actively with their doubly ciliated trochal disks distended, they extend beyond the circumference of the jelly, but still retain attachment at the center, and in that condition there is no other microscopic object of greater beauty.

The jelly serves as a common carapace for the entire colony, and each animal slips out and in through the soft roof of its house without leaving the slightest trace of its passage.

As the animals retract, the large four-lobed trochal disks are folded carefully inwards, and are seen as shapeless masses, over which the body of each closes, protecting the delicate organs and concealing for a time the only apparent structural ruin.

The rotatoria are arranged by systematic writers under eight families, according to the characters of the ciliated disk, and the presence or absence of a carapace.

Our animal has a trochal disk, divided into four principal parts, with small secondary lobes, often between the primary ones. There is no individual carapace, but a gelatinous one, *common to the entire colony*. It must be placed, therefore, among the Flosculariæ, until the present confusion in the classification of the rotatoria shall disappear. The Flosculariæ have many genera, based also upon the anatomy of the ciliated disk and the presence or absence of eyes. These animals have two so-called eyes in the young state, but they disappear in mature life, and this is a common thing among these singular creatures—they get wider awake as their eyes fade out. What microscopical oculist *knows* that these specks *are* eyes?

This brings us to the genus *Melicerta*, where it doubtless belongs, although the description of *Melicerta*, in which each animal has a separate carapace, does not apply.

It seems to be an undescribed species. From *Melicerta ringens*, the only species in the books and well known to all, it differs widely, in having one common carapace for the colony.

Dr. Hunt proposes to call the animal *Melicerta Emilii*, after his youngest daughter.

In closing his lecture, the Doctor said he did not desire to pursue any department of natural science as a dry abstraction. He is content if he can obtain from the common objects among which his life has been cast just that which his nature needs for education in its widest sense, and for compensation, if he can persuade others to do likewise. No one teacher can have the entire truth to communicate

That which is called and taught as science has its errors, and fallacies, and partial statements, and pitiful special pleading, like other departments of knowledge. The poet who clothes human thought in beautiful and elevated language, and gives best utterance to our highest aspirations; the preacher who inculcates self-renunciation and brotherly kindness; the painter or artist who preserves in form or color a loved human countenance or the vanishing splendor of a summer sunset; and the musician who glides into our inner being with melody or song, and fills us with sweet unspoken rapture, are equal interpreters of the truth with the scientific discoverer.

Ideality is not the observing faculty, but it co-ordinates facts and gives them expression.

The highest results of scientific study are *subjective*, not objective; they consist in developing the possibilities of observation and expression of the student, rather than in the many new objects he may discover.

The lecture was illustrated by microscopical preparations and living objects, among which were the jelly glands of *Brasenia* and the lately discovered rotatoria *Melicerta Emilii*.

MOULD AS AN INSECT DESTROYER.

By C. G. Siewers.

The perplexing problem: How shall we check the excessive increase of noxious insects that imperil our crops? has been put in a fair way of solution by the researches of Dr. Bain, a Prussian savant, as recorded by Dr. Hagen, of Cambridge, Mass., in the June number of the *Canadian Entomologist*.

When Pasteur, employed by the French Government to investigate the fatal malady that had attacked the silkworm, made the discovery that the disease was caused by a fungous growth which he styled muscardine, that it could be imparted to healthy larvæ simply by crushing infected ones on their food, and that the disease could be detected, by means of a lens, in the egg itself, and thus the good eggs separated from the bad, he saved from utter ruin thousands of French families whose main support depended on this industry. But he did more. Though he carried his researches no farther, others took up the investigation where he abandoned it, and the result of Dr. Bain's experiments, continued for twelve years, seem to have established the following facts:

That the mould of the mash tub, known as yeast, the mould that infects flies and fastens them to our walls and windows, the common mould of cellars and damp places, and the mould that attacks certain water plants, are but different developments of allied species of fungi, and alike fatal to certain species of insects that are brought into contact with it; and that the disease was developed in France by moist food, lack of ventilation and cleanliness, is probable, and though many were able to pass through all stages, their infected eggs spread the disease through the land, and in this way became epidemic.

I have just had an unpleasant experience of the effect of mould in the loss of a full-grown imperial walnut larva that I had reared from its first moult. Its food was inserted in wet sand in a covered tub, and before I was aware its droppings and food were covered with mould. Fresh food, a sun bath, and change of quarters were of no avail; it refused food for four days, then dropped from its perch a moist discolored mass.

In an article in the *Canadian Entomologist* (1877) I gave an account of a large colony of Callimorpha larvæ, a species by no means common generally, and of my failure to bring one larva in two hundred to the pupa state. They were all taken at maturity, like the French silkworms, with a purging of whitish serum. The weeds on which they fed in the woods were also covered with their dried skins. The next year they were as rare as ever.

In the spring of 1874, the shade trees of our town, Newport, Ky., were attacked by legions of small gray caterpillars, spinning up and destroying the foliage, and invading doorways in such multitudes that the house broom was in constant requisition. Fine shade trees were hewn down, or fearfully lopped of their branches to abate the nuisance. They attacked the silver poplar in preference to all others, a tree singularly free from caterpillars heretofore. I found a small tree in my yard badly infested, and promised two small boys one cent a nest for all they got down with not less than twenty-five in a brood, and burning them as they were brought me, paid them ninety-seven cents for their hour's work. What was to be expected the next year but the total ruin of every shade tree; but my payment to the same boys was but forty cents, and the next year not one was to be found, and they have never returned to vex us. Continuous wet and cloudy weather may be sufficient to infect with fungus the food these caterpillars eat, but wherever we turn our eyes we find the provisions of nature ample to repress surplus life on this globe, and in no case more so than in our own species, where the half that survive infancy are winnowed out by sword, pestilence, and famine, till but a corporal's guard can be rallied at our allotted term of threescore years and ten.

The cases I have described are by internal poisoning; I will add one where the poison fungus acted externally. My first attempt to carry through the winter that hibernating larva, the black bear (*Ecpantheria*), proved a total failure, as I put them away in the cellar where they were attacked and covered with mould, and though I washed and brushed them apparently clean, dried them in the sun, and kept them out of doors the rest of the winter, they all died in the spring, refusing all food. Put away the next winter in leaves and brush, in the open air, I lost but one in ten. Exposed all winter to snow, frost, and rain, under chips and wet leaves, coming out in the spring to feed, distended with moisture, they are perfectly healthy, for no fungus spores have been able to fasten upon them. That prolific oak larva, *Anisota senatoria*, is also a badly infected species, which makes it rather lucky for oak trees, for but few of them ever come to maturity.

Experiments with diluted yeast should be tried on the potato bug, tobacco, army, and cotton worm, and on the grasshoppers of old pastures and clover fields. The proper policy is not to kill, but simply to infect them that they may disseminate the poison. But while we fill the air with fungus spores let us have a care to discriminate between the just and the unjust; in slaughtering the Colorado bug and grasshopper, let us not also lay violent hands on our honey bee, on our harmless and beautiful butterflies, and on the various insects that sport in the sun and enliven the face of nature. The bugs and the worms that annoy us can easily be kept in check, as I have shown, by paid handpickers.—*American Naturalist.*

ZINC VEINS AND WORKS OF LEHIGH VALLEY.

Zinc ore was first discovered in Pennsylvania on the site now occupied by the small village of Friedensville (Village of Peace), in Lehigh County, in 1845. The village stands at the head of the beautiful Saucon Valley, rich in an agricultural sense, and doubly so in minerals—iron and zinc. In 1847 William Theodore Roepper, a resident of Bethlehem, and later Professor of Mineralogy in Lehigh University, from a pure love of science wandered over the spur of the South Mountain, that separates the Saucon Valley from Bethlehem, and was shown by a farmer (Ueberoth) a mineral that had puzzled the local mineralogists to classify. He pronounced it to be "calamine," or native carbonate of zinc. This haphazard discovery led to the development of the apparently inexhaustible mines that have for more than a quarter of a century supplied the large works of the Lehigh Zinc Company at this place. The works were erected by Maj. Samuel Wetherill, now of Philadelphia, in 1853, for the production of zinc oxide, in furnaces, by a process of Maj. Wetherill's invention. The works cost $85,000, and on October 13, 1853, they produced the first zinc-white ever made in America. Maj. Wetherill commenced his experiments as early as 1850, believing that it was possible to substitute the oxide of zinc for white lead for paints. In 1852 he successfully invented his "furnace process." This, combined with the "bag process" of Richard Jones, Esq., made the matter possible. Before completion the works were blown down by a tornado, but immediately rebuilt, Charles J. Gilbert, Esq., of New York, being Maj. Wetherill's partner. The works had an annual capacity of 2,000 tons. Up to 1857, when Messrs. Gilbert & Wetherill sold out to "the Pennsylvania and Lehigh Zinc Company," the product had been 4,775 tons of oxide. This company was composed of New York capitalists, with a capital of $1,000,000, and Thomas Andrews, of New York, was the first president. Maj. Wetherill continued in the superintendence of the works until 1857, when he was succeeded by Mr. Joseph Wharton, of Philadelphia. The latter leased the works, and his financial ability and his means and credit floated the concern through the financial storm of 1857. In 1860 the title of the company was changed to the Lehigh Zinc Company, and it is now a strictly Philadelphia company.

These works produced the first *metallic zinc* made in America. Maj. Wetherill had made many experiments looking to the production of metallic zinc, but had been only partially successful. In 1859 Mr. Wharton contracted for the erection of spelter works, and their erection was intrusted to Mr. Louis De Gee, of the firm of De Gee, Gernant et Cie, of Ougree, Belgium, who had been induced to come to the United States for this purpose. These works were put in successful operation, and produced the first metallic zinc in July, 1859. The operatives in this department were at that time imported from Belgium, and importation of Belgian experts and workmen have been frequent since. These spelter works have been in active operation from that time, and during the Franco-Prussian and Turko-Russian war the European demand upon the works was very large for the manufacture of cartridge cases.

In all that pertains to the original in the application of zinc these works seem to lead. The first sheet zinc, as well as the first spelter, was here made. Under the superintendence of B. C. Webster, Esq., then and since 1863 president of the company, a mill for the rolling of sheet zinc was erected in 1864 and 1865. Alex. Trippel, who had been sent to Europe to acquaint himself with the production of sheet zinc, had supervision of the erection. The first sheet zinc in America was rolled in these works in April, 1865.

Before describing the mines that supply all these works, and which are a wonder in their way, a brief description of the buildings and the process of manufacture will not be without interest. The old oxide works include about two acres of buildings, furnaces, tower, dry room, bag room, and packing houses. The ore for this purpose is ground fine by a stone crusher, and then carefully mixed with coal known as "buckwheat," next in grade to "pea." It is then transferred to the furnaces, of which there are fifty-four, with 1,390 feet of grate surface. Within these the mixed coal and ore is reduced by the direct action of heat and the cold blast upon a furnace bed having a multiplicity of small holes, each producing the reducing flame of the blowpipe. The zinc oxide rises, passes through a huge combustion flue to a large circular tower, 50 feet high, in which the oxide and ashes separate. The ashes being heavier than the oxide, the velocity of the fans which impel the product forward lifts the oxide to the top, and the ashes drop to the bottom. The oxide is forced onward through a cooling room, size 80 by 40 feet, and heated to from 400° to 700° Fahrenheit. Thence the oxide is blown through large flues into the "bag" room. This is a huge building, devoid of furniture, excepting long bags of muslin, 45 feet long, in which the oxide is deposited. It is now white as snow, and, after being kiln-dried and bolted, it is placed in bags, and by heavy pressure reduced in bulk, barreled, and is ready for shipment.

The spelter furnaces cover a space about one-half that occupied by the oxide department, taken up by rooms for storing ore, grinding rooms, dry room for retorts, pottery, reverberatory furnaces, and spelter furnaces. Of the latter there are thirty-two. The ore, having been ground and mixed with coal, passes through the reverberatory furnaces. In calcinating it changes from a blue blende to a deep yellow. The sides of the furnaces bristle with retorts. These are charged with the calcined blende, the mouth of each being covered with a fire-clay condenser. An intense heat is maintained by fires beneath, and condensation takes place within the cones. The metal is then drawn out into ladles poured into iron moulds, forming ingots about 1¼ inches deep and 7 by 22 inches in size. When cooled the metal is ready for the sheet mill or the market.

The rolling mill is a brick structure 108 by 64 feet. The sheets are heated in ordinary annealing furnaces, and are rolled by ordinary two-high sheet rolls. The secret of polishing the plates consists in rolling numbers of them at a time and changing their position in the "pile," the friction doing the work. As early as 1857 Maj. Wetherill had sent some metal to the sheet-iron mills of the Messrs. Wood, which was successfully rolled and showed the malleability of the metal. The polish was wanting. When Maj. Wetherill first saw the simple process by which the metal was polished—and considered how much thought, time, labor, and money he had spent in trying to find the secret—he relieved his mind with a cavalry man's expletive and walked away. The sheets are cut into any size desired, and a recent invention enables the company to cut circular plates for stoves, of which there is a large demand. The American sheet zinc supplies not alone the home market now, but much of it is sent abroad. It is fully up to the standard of the popular "La Vieille Montaigne" of France, and because of its freedom from arsenic and iron is often preferred.

The capacity of these works is as follows: For oxide of zinc, 3,000 tons per year; for metallic zinc, 3,600 tons per year; for sheet zinc, 3,000 casks, or 1,800 tons, or about one-half the annual consumption of the country. From 300 to 500 men are employed by the company, and 40,000 tons of coal are annually consumed.

All this has grown up from Prof. Roepper's discovery in the Saucon Valley, and it is worth while returning to this point. The mines are four miles away from the works, and all the ore is hauled by heavy teams over the rough mountain roads. The consumption of ore taken from these mines has reached the enormous quantity of 19,000 tons in a single year, including rich blende, which has been developed in the progress of mining. The main shaft is 250 feet deep, and the valley is arched and tunneled and cut away to a great depth and in a perfect network to get at the seams of the veins.

All about are evidences of a violent upheaval in the long ago, and in the crevices between the rocks the calamine or blende is found, with veins of iron ore at times mixed with the zinc veins. The veins are followed under, over, and around huge rocks, which are carefully propped up, and the leads are a perfect labyrinth of rocky-begirt aisles, a wonder to behold, and a rare study for the geologist, the metallurgist, and the engineer. But the curiosity of the mines is the monster engine—believed to be the largest and most powerful in the world, and, in honor of the efficient President of the company, happily named "Webster's Unabridged." At an early day, and at a shallow depth, water was encountered in working these mines. It was overcome by a small pump, worked by a single horse power. Later this was followed by a donkey pump, still used for dressed ores. Then, as the mines went downward, came a Burdon engine of 30 horse power. This was followed in 1863 by a Corliss engine of 100 horse power, working a series of centrifugal pumps, which found their limit at a depth of 65 feet, with 1,500 gallons of water per minute. But the water came faster than the pumps could remove, and the company decided to make some lasting provision for controlling it, by establishing power to raise 4,000 gallons per minute from a depth of 150 feet, if so much should be found, and to this end they erected and started, in 1865, an engine of 32 inch cylinder and nine feet stroke, working two 22 inch lifting pumps, to which a third 22 inch lift was soon added, with 17 strokes per minute, and the shaft carried down to 122 feet, in 1866, when it encountered and raised 5,600 gallons, and there found the limit of its capacity.

Mr. John West, the engineer of the company, had already matured a plan of engine, pumps, and shafts, for raising 12,000 gallons per minute from a depth of *three hundred feet*, and in December, 1868, the company contracted with the Messrs. Merrick, of Philadelphia, for this new engine, and a year later with Messrs. I. P. Morris & Co. for the pumps, boilers, and mountings. The timber for shaft and pump-rods was brought from Georgia. This engine and its pumping apparatus were set in motion January 19, 1872, in the presence of a large concourse of people, and amid interesting ceremonies. A technical description of the engine is not wanted, but the following particulars will not be uninteresting: The engine has a pumping capacity of 17,000 gallons per minute (and has run to 19,000 per minute in an emergency), raising water from a depth of 350 feet. The engine alone weighs 650 tons, and including the pumps and boilers, the total weight of the machinery is 1,000 tons. The cylinder is 110¼ inches in diameter; length of stroke, 10 feet. The heaviest pieces of iron in the engine are the sections of beams, which weigh 24 tons each. The fly-wheels, of which there are two, weigh 75 tons each; crank pins, 1 ton each. The piston rod is 14 inches in diameter. The cross-head weighs 8 tons. The connecting rods have 9 inch necks, are 15 inches in the middle, 41 feet 2½ inches long, and weigh 11 tons each. There are two air pumps, 50 inches in diameter each. The engine drives four plunger pumps, each 30 inches in diameter by 10 feet stroke, and four lifting pumps, each 31½ inches in diameter by 10 feet stroke, the plunger pumps being uppermost and stationary. The lifting pumps are in the bottom, and are movable, so as to go down as the shaft is sunk. To handle these pumps a steam capstan capable of lifting 50 tons vertically is used.

The foundation that holds this moving mass of iron—and it moves without a jar, is a marvel. The bob-wall of solid masonry, 9 feet thick, was commenced on a plant of solid rock 114 feet below the surface. The foundation for the engine is 32 feet deep below the bedplate. The engine is estimated at 3,500 horse power. The engine is conceded to be the largest fixed single engine in the world, that at Haarlem Meer being a compound engine, with one cylinder within the other. She works comfortably at 12 strokes per minute. Altogether, this engine is a marvel of mechanical skill, and it has attracted visitors from all sections of the world.

This monster is now standing idle. Recently the company discovered a new vein of blende, which they are now working without any interference from water. This vein is not only very rich, but has some very peculiar and desirable characteristics, being available, when worked with brass or copper, for purposes unknown to ordinary zinc—among others, that of making metallic cartridges. The cost of running the large engine was so great that for a time it was feared these works would have to close up. An advantageous contract and the discovery of the new vein have averted this calamity to South Bethlehem. The works occupy ten acres of ground, and their cost has been as follows: Oxide works, $125,000; spelter works, $100,000; rolling mill, $51,000. Total, $276,000.—*Public Ledger.*

THE PROGRESS OF IRON AND STEEL AS CONSTRUCTIVE MATERIALS.*

By Mr. J. A. Picton, F.S.A., Liverpool.

The working and employment of metals have from the earliest ages exercised a most important influence on the progress of the human race. The ancient poets celebrated in song the golden and silver ages, typifying what was supposed to be the primitive state of innocence and purity of our early fathers; but the real advantage and progress of humanity commenced with the use of iron. It would be hardly possible to exaggerate its importance in the economy of human affairs. The employment of iron is a crucial test of the civilization of any people at any period of history. Without it art and science are comparatively unknown, and progress, except to a very limited extent, is impossible. With the free use of iron commenced the dawn of the arts of life. Every invention which contributes to material comfort, every pursuit which tends to elevate humanity, is

* Read before the Iron and Steel Institute.

connected with the employment of iron. A little reflection will show that this must of necessity be the case. The progress of man, whether physical, mental, or moral, is intimately connected with his conquest and mastery of the material elements by which he is surrounded. For this purpose no instrument has anything like the potency which belongs to iron. It is iron which digs the mine, iron which plows the land, iron which reaps the harvest, iron machinery which grinds the corn. It is iron which fells the timber, iron which converts it into building material or decorative furniture. Every department of industry, every art of life, is dependent on iron. It is iron, which out of the rough marble block brings forth forms of beauty and life. It is iron which quarries the stone and shapes it into stately piles of magnificence and grandeur. The exercise of man's constructive faculty to any extent would be impossible without this instrument. What infinite forms of utility or beauty does it assume, from the delicate trinkets of a lady's boudoir, the minute hair spring of a watch, even a dinner card of invitation, up to the ponderous plating of an ironclad, or the mighty percussive stroke of the steam forge hammer. Nature has placed in the hands of the human race no power so potent as steam, which in less than a hundred years has changed the aspect of the world to a greater extent than in all the ages which have gone before; but without iron the steam engine would have been an impossibility. The modern developments of the applications of iron surpass all which have gone before, and are daily extending in magnitude and importance. The railway, with its locomotive speeding along with arrow-like swiftness; the mighty steamship plowing the ocean with its thousands of tons of merchandise; the telegraph wire, like Ariel, putting a girdle round the earth, and annihilating time in bringing together distant regions, are among the latest illustrations of what we owe to iron.

The object of this paper is shortly to illustrate the development and progress of iron and steel as constructive materials. A rapid glance at their history to the present time may aid us in indicating the lines along which their utilization in future is likely to be carried.

WIDE DIFFUSION OF IRON.

Few of the material substances of which the solar system and the earth are composed are more widely diffused than iron. It has been discovered to exist in the solar atmosphere and in that of others of the heavenly bodies. As a mineral, it is found in various combinations over a large part of the crust of the earth. It gives its color to the great Triassic and Devonian systems of rocks. In the living world it is equally diffusive. It imparts its lovely tint to the rose; the flush on the cheek of beauty is owing to its influence. "The ruddy drops that warm the heart" derive their color from the presence of iron. Abundant as it is in nature, it was one of the latest metals brought into use. Flint and stone during countless ages constituted the implements and tools of mankind, succeeded in the heroic age by bronze, the manufacture of which was carried to a high degree of perfection and beauty. The earliest mention of iron is found in the Book of Genesis, chap. iv. 22, where we are told that Tubal Cain was "an instructor of every artificer in brass (or bronze) and iron." The Hebrew word is *barzel*, from a root signifying hardness and strength. We read also of the iron bedstead of Og, king of Bashan, and of Sisera's 900 chariots of iron, 1,300 years before our era.

HISTORICAL USES OF IRON.

In the time of Agamemnon iron was not in general use. No implements or weapons of this metal have been found in the remains of Mycenæ or of Troy. A large iron plate, however, has been discovered in one of the Egyptian pyramids. In the time of Homer iron was a rare and costly commodity, more highly prized than gold. The poet never mentions it as the material of armor or weapons, which were entirely of bronze, but in two passages in the "Iliad" iron axes are mentioned as valuable prizes in the athletic games. Iron was not employed for weapons by the Romans before the time of Hannibal in the second Punic war, but once adopted, the practical genius of the Roman people perceived its advantages, and entered upon its manufacture with avidity. It is not probable that either the Greeks or Asiatics knew the process of extracting iron from the ore. Both iron and steel are found occasionally in a native condition, principally of meteoric origin. Hence it is supposed originated the Greek name for iron, *sideros*, from the same root as *sidus*, the Latin for the starry heavens.

The Romans in Britain practiced the art of extracting the metal from the ore on a large scale. Their works were principally carried on in what is now the Forest of Dean in Gloucestershire, and that of Anderida in Sussex, in both of which enormous quantities of scoriæ and cinders have been found. Their imperfect methods were unable to fuse the ore so as to produce cast iron, and it is probable that the metal was refined by several processes before it was finally adapted for use. The mines had been previously worked, for Cæsar on his arrival found the Britons in possession of iron, though it was employed more for ornament than use. This imperfect method continued down to the sixteenth century, when the introduction of the blast furnace led to the production of cast iron, the manufacture of which was for a long time principally fed from the scoriæ and cinder heaps left by the Romans.

Once adopted, the superiority of iron over every other metal for tools and implements led to the supersession of all other materials for that purpose, and the use of iron entered upon a progressive career, which has extended with the advance of society in an ever-increasing ratio. One of the first purposes to which iron was applied was that of weapons and armor, the manufacture of which attained in the Middle Ages a very high degree of excellence, the hauberks of chain mail of the most intricate and delicate patterns, the chased and inlaid suits of armor, constantly changing its form, exercised the ingenuity of the armorers, and exhibit in the remains left to us a large amount of ingenuity and artistic skill. Offensive weapons were equally elaborated. The Toledo rapier and the Damascus scimitar had a world-wide reputation, and even in England the Sheffield thwittle in the time of Chaucer had become famous for its quality. Ironwork at this period was of the most elaborate description. The locks and keys, the hinges and bolts, the smith's work in gates and screens, exceed in beauty anything of the kind which has since been produced. Many specimens remain both in England and on the Continent, amongst which may be mentioned the iron work in the church of St. Gudule at Brussels, the well-cover by Quentin Matsys at Antwerp, and, though of a much later date, the beautiful park gates at Hampton Court.

EARLY INTRODUCTION OF CAST IRON.

The introduction of cast iron into general use in the seventeenth century effected a considerable change in the application of the metal. Its cheapness led to its extended use in the household economy of daily life; fire gates, stoves, pots, and pans, gates, palisades, pipes, etc. This was no doubt in many respects a great advantage, but it had a very injurious effect on the art of the smith, superseding skill and ingenuity for the deadening process of routine in cast work, and substituting cheapness for excellence. From the seventeenth century onwards, the use of iron in works of magnitude became much more general. Wrought iron having to be worked by hand, was necessarily limited in the size and weight of its productions, but cast iron was capable of applications of a more extended character. In 1755 Smeaton first used large pieces of cast iron for mill and engine work. From that period a leading part has been taken in this country in the development of constructions in iron. It has been well said that the triumphs of iron are principally due to Englishmen; they were the inventors of the steam engine, the railway, the locomotive, iron ships, steamboats, the steam hammer, the telegraph wire, the cast and wrought iron bridges, the ironclads, the monster guns, iron roofs, iron tunnels. One of the first employments of iron on a large scale was in the construction of bridges. In the sixteenth century a proposition was made by Indian Engineers to construct a bridge in cast iron, but the scheme proved abortive. In 1755 an iron bridge was projected at Lyons, to consist of three arches of 82 feet span. Part of the work was actually prepared and put together in the builder's yard, but from some cause not recorded this attempt was also abandoned, and a timber bridge substituted. In 1777 the first iron bridge in England was designed by Mr. Thomas Pritchard, an architect of Shrewsbury, was constructed by Mr. Abraham Darby, of Coalbrook Dale, and erected over the Severn, at Broseley, in 1779. The span is 100 feet, the arch nearly semicircular.

HISTORY OF IRON BRIDGES.

Soon after this date the idea of constructing bridges in wrought iron occurred to several French engineers, and several designs were prepared for works at Paris and elsewhere, but they were not carried out. In 1795 another cast iron bridge was constructed over the Severn at Buildwas, by Thomas Telford, 130 feet span. The boldest conception, however, was the cast iron bridge over the Wear, connecting Monkwearmouth with Sunderland, which was designed by the celebrated Thomas Paine, and was opened in 1796. It consists of a single arch, 236 feet span, with a versed sine of 34 feet. For grandeur of idea, lightness of effect, and economy of material, it has never been surpassed. From that period to the present the construction of iron bridges has proceeded in an ever-increasing ratio, until they have come, in works of magnitude, almost entirely to supersede stone. For some years cast iron bridges had all the sway, constructed either with voussoirs or arch ribs, but have more recently been almost entirely abandoned for structures in wrought iron. Then followed the suspension bridge, of which probably the most graceful specimen is Telford's beautiful structure over the Menai Strait. This was originally designed in 1814 to span the river Mersey at Runcorn, on the site now occupied by the railway bridge; but the means were not forthcoming, and the project slept until revived in 1819 for the new site, and was completed in 1825.

The rapid development of the railway system, from its initiation by George Stephenson in 1830, has called out all the resources of the engineering mind, and led to bridges and viaducts of great boldness and skill. One of the most celebrated of these is the tubular bridge over the Menai, having two spans of 460 feet and two of 230 feet each. A vast amount of experiment, calculation, and research was expended on this design, which no doubt answers its purpose, but with an expenditure of material and an unsightliness of effect which seem to have deterred others from following in its wake. The lattice railway bridge over the Mersey at Runcorn, designed by the late Mr. Baker for the London and North-Western line, is a fine specimen of economy of material and efficiency in the result. Specimens of railway bridges abound on every side, and have developed the capabilities of iron to a wonderful extent. The two largest probably are the viaduct over the St. Lawrence, which consists of twenty-four spans of 242 feet each, and the more recent one over the Tay at Dundee. The latter is the most remarkable specimen of iron bridge building which has yet been constructed. It is two miles in length, consisting of eighty-five spans of various dimensions, eleven being 245 feet between the supports. The construction comprises plate, bowstring, and lattice girders, in wrought iron, with cast iron columns and piers in combination with brickwork and masonry. These are, however, to be surpassed in boldness of design by that projected over the Frith of Forth, the designs for which are not yet published.

IRON IN RAILWAYS.

The railway system has given an amazing impulse to iron construction, but it may be said with truth that it is itself the outcome of the development of iron. Consider for a moment what railways have done for the world. Sanguine expectations were entertained at their inception as to the future results, but it is needless to say that these expectations have been realized a hundred—nay, a thousand fold. What the formation of the grand old highways throughout Europe did for the Romans, the great roadmakers of antiquity, the railway system has done for modern society, but in a far higher degree. It has changed the map of Europe; it has altered the boundaries of states; it has revolutionized the art and practice of war; it has given new directions to trade and commerce. Practically it has leveled the lofty summits of the Alps, and reduced the distance between the Atlantic and Pacific Oceans to a mere question of a few days. It has changed the centers of industry, opened up new sources of wealth and employment, created populous towns where existed only desolate wastes, brought the wild beauties of the lakes and mountains within reach of the toiling multitudes. It is gradually softening prejudices, provincialisms, and peculiarities, and paving the way for the access of that coming time—

"When man to man, the warld o'er,
Shall brithers be for a' that."

It is not too much to say that in a very important sense we owe all this to iron and its development. Without iron these expectations would have been an idle dream; with it the results have become a sober reality.

The motive power and initiative of these grand conceptions is the force of steam, harnessed down and pressed into the service of humanity by genius and skill. I have already said that without iron steam power would have been an impossibility. The progress in each department has gone on *pari passu*. Every improvement in the manufacture of iron has given additional facilities to the steam engine, while steam power has given an impulse to the production of iron which has gone on increasing in more than a geometrical proportion. This will apply to all classes of machinery of which iron may be considered the body, and steam the nervous energy which gives life and motion. The introduction of machinery on any scale of importance is of comparatively recent date, not reaching much further back than a century: yet now we see machinery entering into every manufacture, cheapening the prices of the necessaries, and administering to the comforts of life. Of all this, iron is the basis and essential element.

IRON SHIPS.

Let us now turn to another department, in which, perhaps, more gigantic strides have been made in the use of iron than in any other; I mean its application to naval affairs. The "wooden walls" of old England were formerly the nation's boast, the "hearts of oak" of our tars was the sentiment of every nautical ditty. All this has passed away like a dream, and timber ships, with the exception of small craft for inland and coasting trade, are as obsolete as the canoes of our remote forefathers. One of the first to introduce iron into shipbuilding was Mr. Fairburn, of Manchester, who, in 1830, built three iron steam vessels for the Forth and Clyde Canal Company, and subsequently many others for use at home and abroad. The first sea-going iron ship was the Richard Cobden, built in 1844, at Liverpool, by James Hodgson & Co.; she was 136 feet in length, and 522 tons burden, builder's measurement. Some years elapsed before the example was followed to any extent, when by a sudden impulse, and with common consent, timber was abandoned and iron became the order of the day. With the facilities afforded by iron, enormous progress has been made in naval architecture. The Great Eastern steamship was built in 1858, on the Thames. Her dimensions are 679 feet 6 inches in length, 82 feet 8 inches beam, and 48 feet in depth, fitted with screw engines of 1,600 horse power, and paddle engines of 1,000. Probably she was in advance of her time, the skill in her arrangements not being equal to the grandeur of the conception, but the tendency of late years has been to increase the dimensions, particularly in length. The latest development has been shown in the Arizona, of Liverpool, of the Guion line, and the Orient, of London, of the Australian line; both recently built on the Clyde, of dimensions nearly alike. City of Berlin, of the Inman line, and the Britannic and Germanic, of the White Star line, are still, if at all, inferior in size. The Orient has a registered tonnage of 5,400 tons, with a displacement of 9,500. Her length is 445 feet 6 inches, 46 feet 6 inches beam, depth 35 feet. It will be observed that whilst the length of the Great Eastern is about eight times her breadth of beam, the length of the Orient is nearly ten times her width.

The application of iron to ships of war has probably exceeded the progress in any other department, if we consider the enormous masses of iron employed, and the crucial experiments to which they are subjected. A modern turreted ironclad, with her 10 or 12 inch coating of solid metal, her engines of many thousand horse power, her almost automatic machinery for performing every naval operation, her capacity for destruction in the immense armament she carries, presents a representation of the state of modern society, both in its scientific and social aspects, perhaps as striking and illustrative as can be anywhere found.

IRON FORTS.

Closely connected with this is the application of iron to the purposes of war, whether by land or sea. Within the last few years the contest between the aggressive power of ordnance on the one hand, and the defensive power of iron plating on the other, has been carried to an almost inconceivable extent. The caliber of the gun is increased to pierce the plating, and the thickness of the plating is increased to resist the impact, so that we have arrived at guns of 100 tons and upward, with projectiles of nearly 1,000 lb. weight, resisted by armor plates 10 to 12 inches thick. At what point the contest is to end no man can foresee. Iron, also, is being largely utilized for defensive purposes by land. At the present time the new fort now in construction for the defense of the river Mersey is to have wrought-iron plates for the protection of the gunners, some of which are 20 feet long by 11 feet in height and 8 inches in thickness, weighing 26 tons each. When we look at the ironclads, the rams, the torpedoes, the turrets, the large guns by sea, and the plated forts, the railways, telegraphs, and other appurtenances by land, we see that iron plays an important, perhaps the most important, part in modern warfare.

But while iron has thus so largely been employed for the purposes of destruction and defense, on the other hand it has given facilities for mutual intercourse and peaceful cooperation never before known. The railways I have already mentioned; but we must not forget the telegraph wires which encompass our globe, and form, so to speak, the nervous system of the world. It is iron, and the modern facilities for its manipulation, which enable us so to bridge over space and annihilate time.

IRON BUILDINGS.

The subject is so vast that I might go on enumerating to an almost boundless extent the various uses and applications of iron, which are constantly increasing in their adaptation to every purpose of human society, but time will not permit. I will only notice the progress of iron in another department, that of building construction. The old materials for building were stone, brick, and timber, and with these, especially the first, some of the noblest monuments of art and skill have been constructed. Iron, in ancient times, played a very subordinate part in building. It is only in modern structures that its advantages have been appreciated. At first, cast iron was employed for columns and struts supporting weight, and subsequently for girders and beams, but the treacherous nature of the material when subjected to cross strain rendered its use very hazardous. By degrees, wrought iron, by means of improved machinery for rolling, was rendered adaptable for building purposes. A great impulse was given to its employment by the construction of the Crystal Palace, in Hyde Park, in 1851, in which, for almost the first time, the design was adapted to the nature of the new material. This led the way to further improvements. Rolling mills were constructed to manufacture girders and joists of lengths and sections not previously attempted, and the result has been the employment of wrought iron to a very large extent in roofs and floors. Concurrently with this progressive movement, the demand for roofs of very large span in railway stations have stimulated design, and led to the construction of iron roofs of a magnitude never before contemplated; the width of span in several cases approaching 300 feet, and the large areas covered, as in the stations of St. Pancras, at Birmingham,

and at Lime Street, Liverpool, are such as cast into the shade all former constructions of a like kind.

Iron floors have not in England been adopted to any very large extent, but in France, especially in the new quarters of Paris, they are almost universal. The girders and joists are of rolled iron, with iron laths dropped in between, on which is spread a coating of concrete, rendering the structure perfectly fireproof. Iron lends itself readily to the construction of dome roofs, of which recent specimens are found in the reading room of the British Museum, and in the one recently erected in connection with the Free Public Library, Liverpool.

I have endeavored in the above remarks to give a rapid sketch of the lines along which the progress of iron construction has been advancing. I will conclude with a few words on the direction in which these lines are leading us. Notwithstanding the enormous development of railways both at home and abroad, and the depression consequent on excessive and imprudent expenditure, there can be no doubt that the railway system has still a great future in store. There yet remains much land to be possessed. European enterprise will never cease until all the lines of intercourse where commerce finds its way are provided with railways. The adoption of steel for rails, thanks to the genius and enterprise of Sir H. Bessemer, Dr. Siemens, and others, has much facilitated these operations, and holds out to the British manufacturers the prospect of a profitable employment of their capital.

THE IRON FUTURE.

Machinery, whether locomotive or manufacturing, is undergoing a constant but quiet revolution, consisting in improved economy of materials, rapidity of motion, and increased efficiency. Iron ships, especially steamships, are increasing in size and power, to which the introduction of steel plates will impart greatly increased advantages. In warlike affairs, whether the contest between armor-plating and armor-piercing has reached its acme, I will not take upon myself to say. The final decision of the problem is one of great interest as to the future employment of iron for such purposes. The facilities of iron, especially wrought iron, for all engineering constructions are more and more appreciated year by year; but with some few exceptions there is a great defect runs through them all in the absence of anything of æsthetic taste in the designs. The ancient motto for building was "strength, commodity, beauty." The two first have been attended to, almost to the entire neglect of the third. This I cannot help thinking is a great mistake. The great engineering works with which the surface of our country is studded should have a dignified and noble aspect. They should minister to the sense of beauty and fitness as well as to that of strength and power; but too frequently the reverse is the case. I will refer to an instance or two. The railway viaducts built by Brunel over the rivers at Chepstow and Saltash are grand specimens of constructive skill, but their aspect is repulsive in the extreme. Let any one compare London Bridge, with the graceful curves of its arches and its simple yet elegant design, with the iron bridge of Blackfriars, or still worse, with the railway bridges crossing the Thames; the contrast will be found painful in the extreme. The railway bridge at Runcorn, by Mr. Baker, with its light iron latticework and the sweeping lines of the viaducts on each side, is a fine and noble structure. Telford's suspension bridges at Conway and the Menai are charming in their outline, and fairylike in their construction, whilst their neighbors the tubular bridges are the very incarnation of ugliness. This is a defect not inherent in the material, for iron readily lends itself to any shape of beauty. It rather arises from contempt or inadvertence, looking at strength and power as the only elements required. Let us hope that a better spirit may be evoked, and that our future engineering works in iron may be as distinguished for beauty of design as they are now renowned for grandeur and efficiency.

In architecture, properly so called, iron is doubtless destined to play a very important part. Hitherto, architects as a body have neglected iron. When employed, they have striven to hide it from sight, and seem to apologize to themselves and the world for being obliged to use it instead of brick or stone. Its use, however, is being forced upon us, and on every side we are met with iron sheds, iron churches, iron houses. The designs of these are usually hideous to behold, but why should this be so? Why should architects not face the difficulty, and instead of letting iron master them, convert it into their handmaid and servant? The mediævalists followed a different course. They took the material which lay before them, and, by a happy audacity in design and skill in construction, they produced effects which for composition of masses, picturesqueness of outline, and brilliance of inventiveness have ever since been the admiration of the world.

Looking to the future, there can be no doubt that iron is every day becoming a more important factor in the world's affairs. The ages of stone and bronze, the times of darkness and ignorance have passed away, and with the use of iron came in power, and knowledge, and light. It is destined to work yet greater wonders. It is its mission, sent by a gracious Providence to lighten man's labors, to give him the mastery over nature, to enable him to explore her secrets, to comprehend her laws, and turn them to the best advantage for the welfare of humanity. The ages of gold and silver may serve for the theme of the poet's fancy or the dream of the enthusiast, but the age of knowledge, and progress, and power, and wisdom is the age of iron.

A PNEUMATIC ELEVATOR.

At the Hottinguer shaft of the Epinac collieries (Saone et Loire), France, a system of raising minerals, by Mr. Archibald Alison, has been introduced. The shaft is to be 3,279 ft., of which about two-thirds has at present been sunk. The coal trams to the number of nine are placed one above the other in a cage, which is provided at each end with a piston, working in a large tube reaching the whole depth of the shaft. The cage is raised or lowered by creating a partial vacuum or a plenum above the piston by means of a powerful air-pump. The arrangement consists of either a single tube, in which a cage alternately rises and descends, or of two tubes, coupled together, in one of which a train of empty trams descends while a full train is being raised in the other. When two tubes are used the air pumped from that in which the full train is being lifted is delivered into the other, in which the empty train is descending, and in which there is already a partial vacuum, instead of into the atmosphere, and the weights of the trains thus balance each other, the net load of coal only having to be raised by the engine. The air of the mine, which fills the lower part of the tube as the train rises, is blown out to the surface through an escape pipe as it descends, and the ventilation is thus to some extent assisted.

The cage is retained in any position by stops worked from the outside, and is readily lowered or raised at the stations to bring any trains opposite to the doors, by admitting air over it, or by opening a communication between the tube above it and the exhausting engine. The cage is stopped without shock at the ends of its travels by the cushion of air in the closed ends of the tube; and to admit of stopping at intermediate levels, as well as to guard against accidents, a sliding partition is fitted in the tube immediately below each station, except that at the bottom, which is open so long as the cage is below, but is closed when it has passed. The position of the cage, with its pistons, during the ascent or descent, is indicated in the engine-house by a series of barometers showing the pressure of air in the tube at points 100 meters (109 yards) apart. As the pressure below the cage is equal to that of the atmosphere, while a partial vacuum is maintained above it, the barometers show at once whether the cage is above or below the point at which each of them is connected to the tube. To allow the pistons attached to the cage to fit the tube, even where this is not cylindrical, as at the doors, one of them, that above it, is made double, consisting of two pistons spaced at a distance apart greater than the height of a door, but less than the length of tube between two doors. The pistons are packed with leather, and the tube is lubricated with water mixed with a little soap and oil. It is estimated that the consumption of coal for the boilers of the winding engine, in lifting from a depth of 1,000 meters (1,093·6 yards), would be 10 per cent. of the quantity raised if ropes were used, but will be only 3 per cent. by the pneumatic system, even with a single tube. This is a saving of 145 lb. of coal per ton of coal lifted, equal to 6·6d. per ton, valuing the coal used for the boilers at 8s. per ton. With an output of 450 tons per day, and reckoning 280 working days in the year, this is equal to an economy of £3,528 per year, in boiler coal alone.

[Continued from Supplement, No. 193.]

AMERICAN ENGINEERING.—VI.*

RAILROAD ROLLING STOCK.

In no department do American railroads differ more from those of Europe than in the rolling stock which runs upon them. Originally of cheap and inferior construction, with sharp curves and irregularities of surface, these railroads demanded rolling stock of more flexible character than was needed on the more expensive roads of Europe.

In the construction of cars, this object was accomplished by the use of the independent truck, which enabled long cars to pass without difficulty around very sharp curves, and accommodated itself to the irregularities of the track, transmitting to the body of the car simply the resultant of the movements as felt at the center, where the connection is made with the pin. This truck system is in universal use. The details of the different trucks differ materially, some being largely of wood, and others almost entirely of iron, but the one principle which is everywhere followed is to hang the long body of the car on two independent trucks, which are free to rotate on pins, and which follow the curve of the track, while the body of the car takes the position of a chord. The only exceptions are in short cars used for coal and other heavy freights, which have but four wheels, and a few larger coal cars of a peculiar design in which the axles are kept parallel, but free to move transversely for a moderate distance.

American railroad cars may be grouped under the two general classes of passenger train equipment and freight train equipment.

The passenger train equipment includes, besides the coaches in which passengers ride, the baggage, mail, and express cars which are carried on the same train. An express train on a long line is usually made up in the following manner: a mail car, placed next to the engine, and provided with all arrangements for distributing mails, and for receiving and delivering mail bags at stations where the trains do not stop; an express car used exclusively for express freight; a baggage car for the baggage of passengers on the train; two or more day passenger coaches, each seating about 54 people; one or more sleeping cars. On some of the less important lines a single car, divided into compartments, is made to answer for mail, baggage, and express, while, on the other hand, on many railroads much longer trains are required. A fully equipped first-class passenger train is illustrated by the photographs of a train on the Pennsylvania Railroad, with a description of each class of cars.

The principal varieties of freight cars in use are: the flat car, a single uncovered platform; the box car, a house car with doors on the sides; the stock car, with tight roof, but sides made with open slats for carrying cattle; the oil car, which consists of a platform carrying an air-tight boiler-shaped tank of iron; and the coal car, of which there is a great variety of patterns. All of these cars, except the coal cars, are built with two trucks and eight-wheels of chilled cast iron, and measure about 30 feet in length as they stand in a train. For grain and general merchandise the eight-wheel box car is universally used. These cars weigh from 17,000 to 20,000 pounds, and carry from 22,000 to 28,000 pounds. A freight train is made up of freight cars of different varieties, to which is always added at the rear a "caboose," which is a small car of plain construction, in which the tools, lamps, and outfit of the crew are carried, and which is the headquarters of the conductor of the train.

The standard American locomotive for both passenger and freight traffic is the eight-wheel engine. The first engine of this class is said to have been designed by Mr. Henry R. Campbell, of Philadelphia, in 1836, though the "equalizing beams," by which the weight is distributed on the driving wheels, were introduced somewhat later by Mr. Joseph Harrison, Jr. The forward end of the engine rests on a four-wheel truck, which carries about one-third of the whole weight, the other two-thirds being equalized on two pairs of driving wheels. In 1851 this class of locomotives had substantially its present appearance, but was different in many details. It was then usual to make the locomotives with cranks and inside cylinders, and the reversing of the valve was accomplished with the so-called hook motion. About the year 1855 outside cylinders and the shifting link valve motion came into use.

The earlier locomotives without side cylinders had a rectangular smoke box, and the cylinders were bolted to it. This arrangement answered very well so long as the locomotives were small, but as their size increased it became customary to make the smoke box round, and to fasten the cylinders to a large casting called the saddle, upon which it rested. This was a decided improvement, but not so good as the present practice of casting one-half of the saddle with each cylinder, the two cylinders being of the same shape and interchangeable.

For switching cars in yards small locomotives, the whole weight of which is carried on two or sometimes three pairs of driving wheels, are commonly used. They are often built with tanks over the boiler, so as to dispense with tenders, but this practice is by no means universal.

Upon railroads where locomotives of greater power than the standard eight-wheel engine are required, the practice was formerly to use a "ten-wheeler," the peculiarity of which was that it had three pairs of driving wheels instead of two, the other features of the eight-wheel engine being retained. On the Baltimore and Ohio Railroad a locomotive of peculiar construction, known as a "camel," has long been in use. The entire weight is carried on four pairs of driving wheels. The cylinders are outside, connecting with the third pair of wheels, and the cab is placed on top of the boiler, directly behind the smoke stack, giving the engine a singularly ungainly look. But the two classes of locomotives which are now generally preferred for heavy freight traffic, especially on heavy gradients, are the "Mogul" and the "Consolidation" engines, both of which are fully illustrated in the society's exhibit.

The "Mogul" has three pairs of driving wheels connected, and a two-wheel swing truck in front, equalized with the front driving wheels. It has rapidly grown in favor for freight service on heavy grades, or where maximum loads are to be moved, and has been adopted by several leading lines. Utilizing as it does nearly the entire weight of the engine for adhesion, the main and back pairs of driving wheels being equalized together, as also the front driving wheels and the pony wheels, and the construction of the engine, with swing truck and one pair of driving wheels without flanges, allowing it to pass short curves without difficulty, the "Mogul" is generally accepted as a type of engine especially adapted to the economical working of heavy freight traffic.

The original engine, named the "Consolidation," was built in 1866 to operate a grade of one in forty on the Lehigh Valley Railroad. It had cylinders twenty by twenty-four inches, four pairs of driving wheels, connected, forty-eight inches in diameter, and a two-wheel swing truck in front, equalized with the front driving wheels. The weight of the engine in working order was ninety thousand pounds, of which all but about ten thousand pounds was on the driving wheels. This engine was the first of a class to which it has given its name, and which are now recognized as the most powerful freight engines in use.

Consolidation Locomotive. Built for Erie Railway by Brooks Locomotive Works, *according to following Specification:*

Dimensions.—Cylinders, 20 in. dia. and 24 in. stroke. Drivers, 50 in. dia. outside of tires. Gauge, 4 ft. 8½ inches. Fuel, anthracite coal. Total wheel base of engine, 22 ft. 10 in. Driving wheel base, 14 ft. 9 in. Weight in working order, total, about 100,000 lb. Weight on drivers, about 88,000 lb.

Boiler.—Made throughout of best quality of Otis steel, $\frac{7}{16}$ in. thick, riveted with $\frac{13}{16}$ in. rivets placed not over 2¼ in. apart from center to center. All horizontal seams to be double riveted; all parts well and thoroughly stayed, and extra welt pieces riveted to inside of side sheets, providing double thickness of metal for studs of expansion braces. All seams to be properly calked. Boiler tested to 180 lb. pressure per square inch.

Waist.—54 in. dia. at smoke box ends; made telescopic, and with one dome placed over fire box; double flanged, smoke box of ½" iron.

Tubes.—Of iron, No. 13 W. G., 200 in number, 2 in. outside diameter, and 135⅛ inches in length between tube plates; 2⅝ inch centers of tubes.

Furnace.—Of best quality Otis steel, 123 inches long and 33⅝ inches wide inside of mud ring, and 44 to 56¾ inches deep from bottom of mud ring to under side of crown sheet (front and back ends); all plates to be thoroughly annealed after flanging; side and back sheets, $\frac{5}{16}$ inch thick, crown sheet, ⅜ inch thick, flue sheets, ½ inch thick, water space, 3 inches at sides and back, increasing in width at top, water space in front, 4 inches; stay bolts, made of best Ulster iron, ⅞ inch dia., screwed and riveted to sheets, and not over 4½ inches apart from center to center.

Crown Bars.—Crown sheet supported by crown bars, made of two pieces of wrought iron, each 4½ in. x ⅝ in. section, set ⅞ inch above crown, placed $5\frac{1}{16}$ inches centers, and bearing on side sheets, crown stayed by braces to dome and outside shell of boiler.

Cleaning Holes.—Cleaning plugs in corners of firebox, and blow off cock in front.

Throttle Valve.—Balance throttle valve of cast iron placed in dome.

Grates.—Of iron tubes 2" outside dia. No. 4 W. G.

Ash pans.—With cast iron frames and slides.

Smoke Stack.—Erie Railway standard.

Main Frame.—Of best hammered iron made in three sections, main frames forged solid.

Front Rails.—Front rails bolted and keyed to main frames, and with front and back lugs forged on for cylinder connections.

Pedestals.—Pedestals protected from wear of boxes by cast iron flanged wedges. Pedestal caps lugged and bolted to bottom rails of frame.

Truck.—Swinging, center-bearing, two-wheeled truck; two double plate chilled wheels of approved make, 30 in. diameter.

Axles.—Of best hammered iron, with inside journals 5 in. diameter and 10 inches long.

Springs.—Of best cast steel, tempered in oil.

Cylinders.—Of best close-grained iron, as hard as can be worked, each cylinder cast in one piece, with half saddle, placed horizontally; right and left hand cylinders reversible and interchangeable, accurately planed, fitted, and bolted together. Oil valves placed in cab and connected to steam chests by pipes running under jackets. Pipes proved to 200 lb. pressure.

Pistons.—Heads and followers of cast iron, fitted with Dunbar packing. Piston rods of best hammered iron, ground and keyed to crossheads, and secured to piston head with brass nut.

Guide.—Of wrought iron, case hardened, fitted to wrought iron guide yoke.

Crossheads.—Of wrought iron, with wrist pin of wrought iron, case hardened.

Valve Motion.—Most approved shifting link motion, graduated to cut off equally at all points of stroke. Links, blocks, pins, lifting links, and eccentric rod jaws made of

* American Engineering as illustrated by the American Society of Civil Engineers at the Paris Exhibition of 1878. Compiled by George S. Morrison, Edward P. North, and John Bogart, Committee, Transactions of the Amer. Soc. of Civil Engineering.

the best hammered iron, well case hardened. Rocker shaft and reverse shaft of wrought iron, with arms forged on, except vertical arm of reverse shaft, which is to be keyed on.

Driving Wheels.—Eight in number, 50 inches in diameter, centers of cast iron, with hollow spokes and rim, and turned to 44 inches diameter to receive tires.

Tires.—Of steel, 3 inches thick when finished, 3 pair flanged 5¾ inches wide, 1 pair plain 6 in. wide, the plain tire to be placed on the main wheels.

Axles.—Of hammered iron, excepting main axle, which is to be of steel; journal 7 in. dia. and 8 inches long. Driving boxes of cast iron, with brass bearings.

Springs.—Of best cast steel, tempered in oil.

Rods.—Connecting and parallel rods of best hammered iron, forged solid, furnished with necessary straps, keys, and brasses. Parallel rod brasses to be babbitted, the grooves for babbitt to run full length of bearings.

Crank Pins.—Of hammered iron, except main pin, which are to be of steel.

Feed.—To be supplied by one injector and one pump, or two injectors, as directed.

Water.—Guide yoke made with lugs for 2 pumps, in case they are required.

Cab.—Substantially built of hard wood, well seasoned and finished, and fitted together with joint bolts and corner plates.

Pilot.—Oak frame and ash slats.

Finish.—Cylinders lagged with wood, and neatly cased with Russia iron. Heads of cast iron, painted. Steam chests with cast iron tops, bodies cased with sheet iron. Dome lagged with wood, with sheet iron casing on body, and cast iron top and bottom rings. Boiler lagged with wood, neatly jacketed, and secured by iron bands.

Furniture.—Engine to be furnished with sand box, brackets, and shelf to receive head lamp, bell, whistle, heater, blower, and safety valve, steam gauge, cab lamp, gauge cocks, oil cans, and tallow pot. Also a complete set of tools, consisting of two jack screws, one pinch bar, a complete set of wrenches to fit all bolts and nuts on engine, one monkey wrench, hammer, chisels, cab seat cushions, poker, scraper, and slice bar.

Painting.—Engine and tender to be painted and varnished.

Gauges.—General features of construction. All principal parts of engines accurately fitted to gauges and templates, and thoroughly interchangeable.

Case Hardening.—All finished movable nuts and all wearing surfaces of machinery to be of steel or wrought iron, case hardened.

Threads.—To be United States standard, as designed by Wm. Sellers for Franklin Institute, of Philadelphia. Absolute accuracy in this insisted upon.

Tank.—Tank strongly put together with angle iron corners, and well braced. To be made of $\frac{5}{16}$ iron, riveted with ⅜ rivets. 1¼ inch pitch. Capacity, 2,500 gallons.

Frame.—Of wrought iron, as per tracing.

Truck.—Of wrought iron frames, with wooden battens; chilled wheels, of approved make, 30 inches dia.; brakes on rear tender truck.

Axles.—Of best hammered iron; outside journals 3¼ inches dia. and 7 inches long; oil-tight boxes, with brass bearings.

Tool Boxes.—Of hard wood, bound with iron, one box at back end of tender frame, and two boxes on top of tank.

First-class Passenger Coach. Built by the WABASH RAILWAY COMPANY.

Wabash Railway, Coach No. 6.—Extreme length of car, including platform, 60 feet 5 inches. Width over all, 10 feet 4 inches. Outside height, 10 feet 4 inches. Car is furnished with Miller platform and wrought iron drawbar. Has two six-wheel trucks. Extreme length of truck, 13 feet. Width, 6 feet 7¼ inches, with wheel centers 4 feet 8 inches apart.

Interior of Car.—Extreme inside length, 53 feet 3 inches. Inside width, 9 feet. Inside height, 9 feet 4 inches. Inside width of upper deck (monitor top), 4 feet 8 inches. Finished with white ash with black walnut trimming. Number of windows, 40—18 on each side of car and 2 at each end. Door at each end of car. Car contains 15 double seats on a side, seating 60 people. Cushions upholstered with red plush, with green plush backs. Saloon at each end of car. Car is heated by two hot-air stoves.

Locomotive and Passenger Train, Pennsylvania Railroad.

The train is composed of a passenger locomotive and nine cars. Westinghouse automatic air brake of the latest arrangements. There are also hand brakes acting independently of the air brakes. Janney coupler, side buffers, and platform recently adopted by the Pennsylvania Railroad.

Locomotive 61 is a Pennsylvania Railroad standard, class "C," locomotive for burning bituminous coal. The cylinders are 17 inches by 24 inches. The driving wheels are 62 inches in diameter. The boiler is of steel, and contains 155 iron tubes, 2 inches inside diameter, 138$\frac{1}{16}$ inches long. The fire grate area is 17·6 square feet, and total heating surface of tubes and firebox, 1,056·98 square feet. The weight of the locomotive ready for the road is 75,500 pounds. The tender has a capacity of 2,400 gallons of water and 8,000 pounds of coal, and is fitted with water scoop for taking up water while running, for which purpose water troughs are located between the rails at certain points.

United States Postal Cars, 24 and 25 (both alike), length 60 feet, width 8 feet 7 inches, height 9 feet 4 inches. The cars have doors at both ends, and two double doors on each side. There are 11 windows on sides, and 36 in upper deck. Each car contains the following furniture:

Bin, 22 feet 5 inches long, divided by upright posts into 5 compartments for storing pouches. Bin, 16 feet 3 inches long, divided by upright posts into 3 compartments for storing pouches. Two racks, 16 feet long, 2 feet wide, with hooks for hanging mail bags. One rack, 5 feet 6 inches long, 3 feet wide, with hooks for hanging mail bags. One table, 2 feet 5 inches high, 26 inches wide, 17 feet 2 inches long, with mail boxes, drawers, and closets underneath. One table, 18 feet long, 2 feet 2 inches wide; one letter case on end table, containing 600 pigeon holes 4 inches by 4½ inches. Two paper cases, containing 16 pigeon holes each, eight being 10 inches wide and 21 inches deep; seven 12 inches wide and 21 inches deep, and one 12⅞ inches by 21 inches deep.

Besides the above mentioned furniture, each car contains a water closet, Baker heater, washstand, closet for clothes, water reservoir, and the necessary lamps. The weight of these cars when empty is about 51,000 pounds each. The average weight of mail matter carried per records is as follows:

General daily average for 70 days..	9,862 pounds.
Daily average for highest 7 days...	15,745 "
Maximum one day	18,537 "

The cars are carried on six-wheeled trucks.

Express Car 46 is of the ordinary style used by the Pennsylvania Railroad. Length of body, 40 feet 1½ inch; outside width, 9 feet 4¼ inches; outside height, 8 feet 1 inch. Sliding doors on sides, 5 feet 6 inches wide; end platforms but no end doors, thus cutting off communication with the train in order to ensure safety of express matter; ventilators on sides but no windows. Hand brake can be applied as well from inside of car as from the end platforms. The weight of this car is about 30,000 pounds. The car is carried on four-wheeled passenger car trucks, Pennsylvania Railroad standard.

Baggage Car, No. 70, is 40 feet 1½ inch long outside, 9 feet 4¼ inches wide outside, 8 feet 1 inch high outside, has side doors, 5 feet 6 inches wide, end doors, 2 feet 1 inch wide, and 2 windows on each side; also end platforms. Hand brake can be applied from inside of car. The weight of this car is about 30,400 pounds. The car is carried on four-wheeled passenger car trucks, Pennsylvania Railroad standard.

Passenger Cars, 574 and 578 (both alike). The length of body is 46 feet 7 inches outside; the width at cornice, 9 feet 8 inches; 10 feet 8⅝ inches high. These cars will seat 54 passengers each. At one end of the car is a cabinet containing urinal and water closet, also the water tank for ice water; on the outside of the cabinet is the water spigot and splash basin. There are fifteen windows on each side, two at each end, besides a glass panel in the doors; the upper deck has thirteen lights on each side; these latter are movable, so as to act as exhausting ventilators. The finish of the car is maple, cherry, and ash. The cars are carried on four-wheeled passenger car trucks. The weight of each car is about 39,000 pounds, without passengers.

Pullman Palace Car, No. 209. The length of car is 58 feet 1 inch; width at eaves, 9 feet 11 inches. It contains, in addition to the main compartment, two drawing-rooms, 6 feet 6 inches by 7 feet (seating five persons each). Total seating capacity, forty-four persons. The car is lighted by thirty-four windows on the sides, and twenty-four ventilators or deck sash openings. The trucks are of the six-wheeled pattern used on Pennsylvania Railroad. The total weight of car, without passengers, is 54,000 pounds.

Pullman Palace Sleeping Car, No. 272. The length of car is 52 feet 2 inches; width at eaves, 10 feet ½ inch. The car contains, in addition to the main compartments, a stateroom 6 feet by 32 inches, seating four persons. Total seating capacity, fifty-four persons. The trucks are of the six-wheeled Pennsylvania Railroad pattern. The total weight of car, without passengers, is 54,000 pounds.

Pullman Palace Sleeping Car, No. 291. The car has a length of 56 feet; a width at eaves of 10 feet 1 inch. The main compartment seats forty-six persons, and the smoking room, 6 feet by 6 feet, four persons. The car is lighted by eight single and thirty double windows, and has thirty-four ventilators in deck, and end ventilation. The trucks are of the six-wheeled pattern. The total weight of the car, without passengers, is 55,000 pounds.

RAILWAY CAR CONSTRUCTION, PAST AND PRESENT.

THE wonderful degree of perfection attained in the construction of railroad cars, as exhibited in the best specimens of passenger and freight rolling stock now in use on our roads, can only be fully realized by contrast with the kind of cars built fifty or even twenty years ago, both in this country and in England. Should the history of this particular branch of railway progress ever be written, it would embrace a multitude of details which can only be gathered by the most painstaking research. Perhaps such a history might not be of any very great practical value, but it could hardly fail to be exceedingly interesting, as showing the rapid growth of ideas in the adaptation of mechanical construction to the almost limitless capacity of steam as a motor for land locomotion.

The cars for carrying passengers on the Liverpool and Manchester road in 1830 were without roofs, the body consisting of floor sills, and side and end framing boarded up. There were no springs, and the journal-boxes were bolted to the sills. In the following year springs were introduced for the purpose of protecting the rigid frame from the shocks of concussion. This improvement could hardly fail to be suggested by the important service rendered by springs in ordinary vehicles. The face of the car wheels were next made conical instead of flat, in order that they might get around curves more easily. A few years later came the class carriages, designated as first, second, and third class, the first having cushioned seats, but quite devoid of any special ornamentation. In addition to these there were "mixed" carriages, so-called, having three compartments, the center one being for first-class passengers, and the other two for second-class. As a specimen of some of the early novelties in the way of passenger coaches introduced into England, we may refer to a compartment coach designed by a Mr. Hanson in 1847, the body of which was of iron. The partitions between the compartments consisted of a light frame-work to which sheets of iron were riveted, a piece of felting being placed between the sheets and the rivet heads. There was but one seat in each compartment, so that the occupants could always ride facing forwards. Foot-rests were provided, consisting of two pieces of board with a space between them lined with sheepskin with the wool on; so that passengers could either rest their feet on the top board, or keep them warm by putting them between the wool linings. There were also head-cushions made of sponge covered with leather or cloth, so as to soften the bumps in case of a sudden jerk. The inventor of these comforts also designed a freight car of iron, with a sliding-door on top for receiving and discharging freight. All of these cars were run of course upon four wheels, one at each corner, as "A. Ward" would say.

Upon all the early railways in the United States previous to 1835, four-wheeled cars of the stage-coach pattern were used, and also upon many of them for a considerable time after that date. The style and pattern of these vehicles are very well represented in the well-known silhouette, representing a train on the old Albany and Schenectady road. The first eight-wheel truck passenger car was designed by Ross Winans, and placed on the Baltimore and Ohio road at about the above date. The body of the car was little more than a large box, with seats inside and on top. Others followed, some of which resembled three coach-bodies combined in one, with side-entrances for each compartment—the seats running crosswise. The idea of a central aisle was at length broached, with doors at each end of the car instead of at the sides. This was gravely objected to at first by a solemn board of directors, on the ground that the aisle would practically be nothing more than a long spittoon. At about this time, or perhaps a little later, some rather peculiar cars were built for the Rochester and Batavia road, in New York. They were of the four-wheel type, with three compartments, the central one being elevated some three feet above the other two, giving the cars a humpbacked appearance like a camel. They were not ill-looking on the outside, but inside they were models of inconvenience. The freight cars for carrying wheat were huge hoppers, with a hinged cover at the top and a valve at the bottom. The first eight-wheel passenger car used in the State of New York was on the Auburn and Syracuse road—such at least is the tradition. The sides of the car were framed in lattice style, and in conformity with this the windows were diamond-shaped, and arranged to slide either up or down. The wheels and axles were similar to those now in use, except that the axles were very much smaller—the journals ranging from 2 to 2¼ inches in diameter. Any larger size was not used in order to avoid the supposed increase of friction. Upon some of these primitive eight-wheel cars the truck frames were suspended below the journals for the purpose of diminishing the vibration. The journals were lubricated by means of a box of grease placed in the housing, so the grease would be melted by the frictional heat and run down on the journal.

These several examples of early construction indicate the line of progress through the various stages, until the permanent features which distinguish our present cars became established. From these features there has been no retrogression, nor is there likely to be any. The trucks, with their center bearing, the central aisle, and the end doors and platforms, are not likely to be superseded by anything better. The need of sleeping accommodations for passengers began to attract attention as long ago as 1852, when a car seat was designed something after the fashion of an invalid's chair, with a movable back and lower portion, the seat proper remaining stationary. This enabled the occupant to transform his seat into a sort of lounge upon which he could recline and extend his limbs, and was the initial movement which subsequently culminated in the present luxurious sleeping-car, and also the combined sleeping and drawing-room car, with their enormous excess of dead weight. It is conceded by most railway men that the present style of American locomotive is not susceptible of any material improvement in its general construction, and it will surely be admitted that the maximum of weight has been reached for existing road-bed and track. The same may also be said with respect to cars of the various kinds now used in passenger service, including the best style of day-cars, and what are designated as hotel, sleeping, and drawing-room coaches. There has been a marvelous progress thus far, but aside from subordinate details, it is reasonable to assume that the goal has about been reached.—*National Car Builder.*

HOG CARS.

A UNION PACIFIC stock car went East recently loaded with hogs, and was the delight of every hog shipper that saw it. The car had a water tank under it that would hold about twenty barrels of water, to which was attached a pump that was operated from the roof of the car. On the under side of the roof were two or three leaden pipes that were little less than sieves on the lower side, and when the shipper wished to water his stock, all he had to do was to climb to the roof of the car and do a little pumping, which would give the stock in the car a complete shower bath. The operation could be done as well while the train was moving as standing still. The car was also partitioned off in sections, preventing stock from crowding into one end of the car and piling upon each other.

THE DYNAMICAL POWER OF STEAM.

AT a time like the present, when economy in every department of mechanics and manufacture is eagerly sought after, it is somewhat strange that no efforts should be made to utilize, on a large scale, the dynamical energy of steam. This is, perhaps, owing to the fact that the form of dynamical energy in steam is not much known or recognized beyond its limited application to injectors and ejectors. The work to be obtained from steam, whether used statically or dynamically, may be compared, theoretically, very considerably to the disadvantage of the former method. The statical use of steam is the system at present represented by a reciprocating piston in a cylinder, where the expensive pressure of the steam is alone used, the velocity of admission to the cylinder being rendered purposely as moderate as possible. The condition of dynamical energy would be that of an escaping jet. It may be thought, at a first glance, that an escaping jet of steam represents no useful condition for work; but this idea is evidently a fallacy, as this form of energy is very advantageously made use of in the injector or ejector pump. In this class of instrument there cannot possibly exist any form of statical energy, as they are invariably constructed with an overflow orifice open to the atmosphere. The condition of work here is evidently a certain weight of steam per minute rushing into the atmosphere, or even into partial vacuo, with a great velocity, and thus inducing or drawing to itself a much heavier weight of water, which, mingling with the steam, acquires a portion of its velocity in inverse ratios to their respective weights, and at the same time producing a partial vacuum which tends to accelerate the issuing jet of steam. The resulting volume of water and steam has thereby acquired a momentum which is sufficient to overcome the statical resistance of the check valve and the boiler pressure behind it.

This condition of matters is highly instructive from the point of view that it is thus demonstrated to be possible, that steam generated under statical pressure may, by combination with a volume of water much heavier than itself, be rendered capable of overcoming its own statical resistance. It is also a self-evident axiom, that the total momentum of the effective column of water and steam will remain the same as that of the original escaping jet of steam, less loss by friction. The conclusion is therefore perfectly logical that the total dynamical energy of the escaping jet of steam was perfectly capable of overcoming the original statical pressure of its generation. This is a curious point for further investigation. It is not difficult to make an arithmetical comparison between the dynamical energy of a given weight of steam and the known work usually obtained from it by the ordinary method of working in the cylinder of a steam engine. First, the velocity of an escaping jet of steam into vacuo may be calculated in the same manner as that of an escaping jet of water, and from the formula $v^2 = \sqrt{gh}$, where "v" is the velocity in feet per second,

"g" is "gravity" and "h" is the imaginary head in feet of the fluid in question, of incompressible density, that would suffice to produce the given pressure of investigation per square inch on the orifice. As steam at atmospheric pressure is about 1,700 times lighter than water, "h" would represent a value of about 59,000 for each atmosphere of pressure. For four atmospheres of pressure $v^2 = 2 \times 32 \times 236{,}000 = 15{,}104{,}000$, and the whole actual energy of the steam may be represented by its *vis viva* $= \frac{Wv^2}{2g} = 236{,}000$ foot-lb. per lb. of steam. But it is well known from practice that about 23 lb. of steam are required per hour to indicate one horse-power per minute in the best class of engines $= 33{,}000 \times 60 = 1{,}980{,}000$ foot-lb. per hour = about 86,000 foot-lb. per lb. of steam, or rather more than ⅓ of the above expressed dynamical energy.

The effective value of the dynamic power of steam having thus been fully shown, it only remains for the practical engineer to devise, if possible, a feasible method for its utilization. We have previously observed that it is already used for the injection or ejection of liquids, where the principle is made use of that steam of exceedingly light weight, but very high velocity, may be made to set in motion a much greater weight at a reduced velocity so that the resulting momentum remains the same. So far the principle of dynamic force has been fully utilized, but we have stopped its application at that point, and have not been able as yet to apply such a motive power to produce constant rotation, which is the special development of force most generally required for industrial purposes. We have heard a rumor lately of a French invention which proposes to effect this development in the sense of producing a constant motion from a dynamic development of the elastic force of steam. For motive purposes this utilization can only be in the form of a moving column of water, which by its greater weight and reduced speed may be possibly converted into an active and constant power-producer. From our view of the subject, however, it will be difficult to construct any mechanical appliance to utilize such a moving stream which shall not at the same time waste so much by leakage and friction as to spoil its economical effect. In seeking such a mechanical utilization of dynamical power, we should approach very closely again the forms of continuous rotary engine which have so long been unattainable in an economical form. We believe, however, that in this class of motor it has never been attempted to utilize a moving fluid denser than steam, such as water, and which latter, we would observe, may be just as easily set in rapid motion as steam itself. Now, the utilization of a rapidly-moving stream of water is not such a difficult problem. It is already done every day with an advantage of 75 per cent. effective out of the moving power. If, therefore, our calculations be correct, as to the dynamic force of an issuing stream of steam, and if this jet of steam, at an enormous velocity, can be converted by amalgamation into an immensely heavier and slower stream of water, we may assume, even on this basis, an effective utilization of the power of steam, some two and a quarter times greater than by the statical method at present in use.

Again, it is stated broadly that in screw propulsion, motion is produced by the reaction of a column of water moving rearwards in a line with the keel of the vessel, and that the resulting speed is in proportion to the velocity, homogeneousness, and absence of eddies in this column of water. It would seem that the condition of such a moving column could be most easily produced by the dynamical action of a jet of steam as previously described rather than by the broken and churning action of a screw-propeller. Should this prove to be the case, the revolution produced in marine propulsion would be incalculable. There are many other branches of applied science in which this dynamic energy might be utilized. For instance, compressed air is now very largely used in connection with underground workings. The dynamic force of steam is already used direct for inducing exhaustion for purposes of ventilation, and to induce a current for blowing and similar purposes, but it is never worked up to any considerable pressure. For such an object direct induction between the steam and the air would be impossible, but if water were used with the dynamic jet of steam to give weight and impact thereto, such a system might be available to generate air pressure even to 50 or 60 lb. per square inch.—*Iron.*

THE CASTING OF THE 100-TON GUN IN THE TURIN GUN FOUNDRY.

THE following article has been translated from the *Italia Militare* by Lieut.-General H. H. Maxwell, C.B., R.A., for the "Proceedings" of the Royal Artillery Institution: On the morning of Wednesday, the 30th January, 1878, there was cast in the gun foundry of Turin a gun of a caliber of 45 cm. (17·72 in.), which when finished will weigh 100 tons. The casting took place in the presence of the General Commanding the Division, General Bonelli, the General Commanding the District of Artillery, and General Rosset, the Director-general of Artillery, who proposed the gun and the method of its construction as far back as the 1st February, 1875.

The casting, whether for its size, or still more for the limited means available for the work, is certainly one of the most important ever executed in Italy, and one the success of which assuredly does much honor to our artillery. We may, therefore, expend a few words in demonstration of the importance and difficulty of the work.

The 100-ton gun under construction is of cast iron, breech loading, hooped with three concentric strata of steel rings, analogous to the 24 and 32 cm. (9·45 and 12·20 in.) guns. Its total length is ten meters (32·8 ft.), the caliber is 45 cm. (17·72 ins.), the external diameter of the hooped part is 1·862 meter (5·92 ft.). It is to fire a projectile of about 1,000 kilos (2,205 lb.). The cast-iron part of the gun—that which has just been run—will weigh, when finished, about one-half the weight of the finished gun.

The system of casting adopted was that of Rodman, now in use for other guns of large caliber—that is, the siphon method, with a core cooled from the inside by cold water. The mould, of dry sand inclosed in keyed-up cast-iron boxes, was placed upright in a pit dug on purpose, and strutted up firmly therein. Three siphons of different lengths, opening into the mould tangentially, carried the metal in succession into the mould from the channels immediately above them. Inside the core, made of a tube of wrought iron covered with loam, was the water pipe. The mould measured thirteen meters (42·7 ft.) in length over all; its internal cavity for the gun and deadhead was twelve meters (36·1 ft.), having a maximum diameter at bottom of 1·23 meter (4 ft.), and a minimum diameter at top of 0·87 meter (2·85 ft.), so that the breech of the gun was downward. The core has a maximum diameter at bottom of 40 cm. (1·3 ft.), and a minimum above of 34 cm. (1·1 ft.).

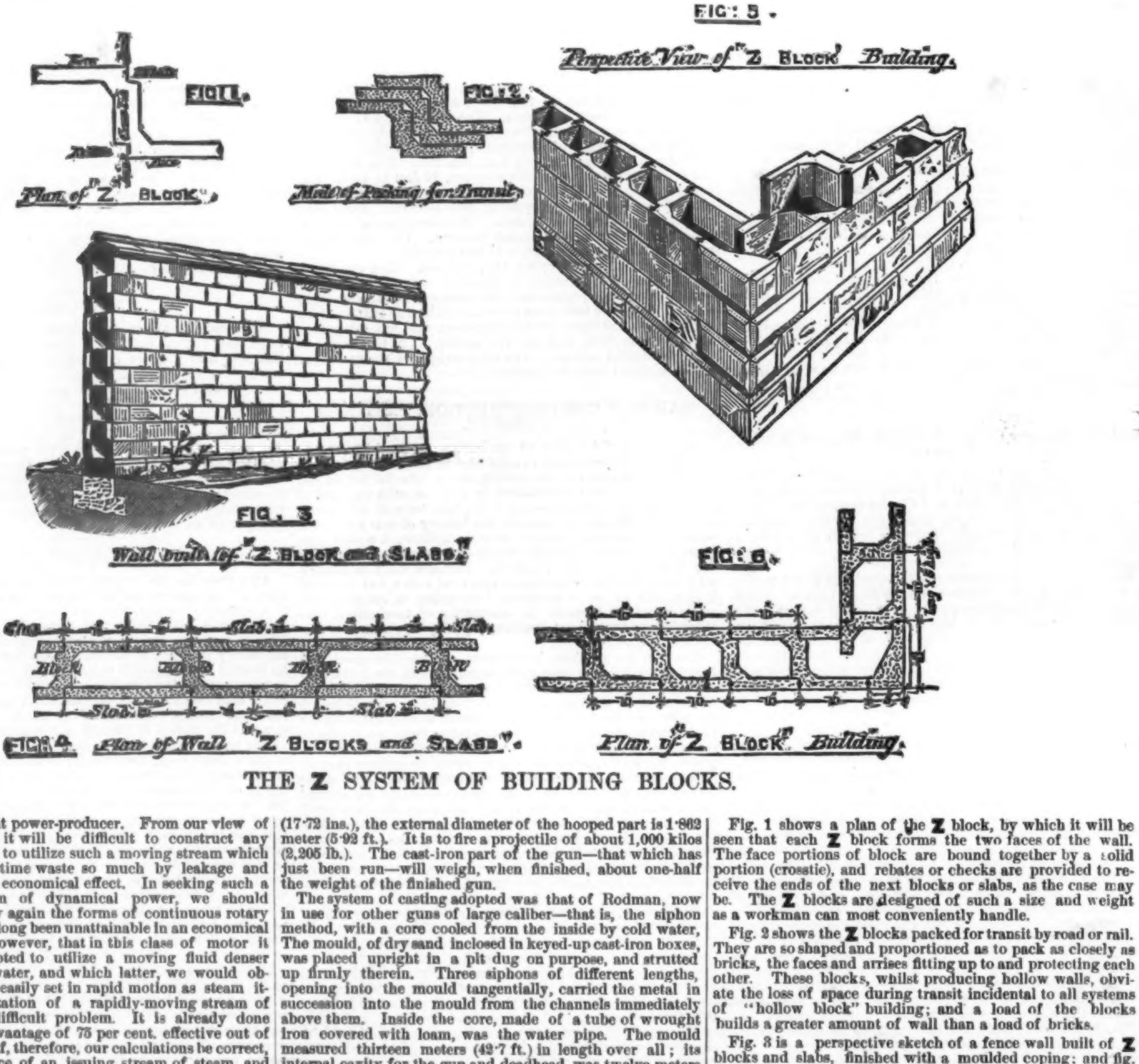
To fill such an enormous cavity and its siphons there was required a mass of some sixty-six tons of cast iron. This would have involved no great difficulty if reverberatory furnaces capable of containing the full charge had been built round the pit; but no such appliances existed, nor was it deemed advisable for a mere first experiment to spend a large sum of money in building new furnaces. Thus the foundry, confined to existing constructions, was compelled to face the exigencies of the casting with four large reverberatory furnaces standing round the pit capable of holding a charge of forty tons, and six small reverberatory furnaces capable of holding a charge of twenty-seven tons, but situated in a neighboring building at a distance of from 80 to 100 yards from the pit. The metal to replace casual loss, and to feed the deadhead on the shrinking of the casting, was to be furnished from old guns run down in a small furnace.

The transport of the metal from the smaller reverberatory furnaces to the pit was effected by three ladles capable of containing nine tons each. They were maneuvered by the foundry hydraulic crane. The operation of casting was brilliantly successful. The transport of the molten metal in successive trips took thirty-five minutes; the metal of the ladles, mixed with that of the reverberatory furnaces, passing through the channels, poured down the siphons and filled the mould in nineteen minutes; after which the water was turned on to circulate in the core to initiate the cooling. The feeding of the deadhead was carried on for four hours, requiring a little more than five tons of metal. Judging from the regular and precise way in which the casting was effected, it may be taken as highly probable that the block will be perfect.

The transport of such an enormous amount of molten metal, combined with the necessity of a rapid and uniform flow of the whole mass properly mixed, constitute without doubt an operation of unusual difficulty; and the excellent result is a proof that every arrangement necessary thereto had been properly made. The success redounds to the credit of the general who proposed the gun, of the intelligent direction of Colonel Giovanetti, and of the co-operation of the hardworking establishment of the Turin foundry, among whom the foreman, Mr. Daguino, deserves especial mention. In a few days the work on the casting will be commenced, and we may reasonably hope that it will be completed in a year.

THE Z SYSTEM OF BLOCK BUILDING.

WE give illustrations of a system of Z block building by Mr. Joseph J. Lish, of Bucklersbury, E. C., and Newcastle on-Tyne.



THE Z SYSTEM OF BUILDING BLOCKS.

Fig. 1 shows a plan of the Z block, by which it will be seen that each Z block forms the two faces of the wall. The face portions of block are bound together by a solid portion (crosstie), and rebates or checks are provided to receive the ends of the next blocks or slabs, as the case may be. The Z blocks are designed of such a size and weight as a workman can most conveniently handle.

Fig. 2 shows the Z blocks packed for transit by road or rail. They are so shaped and proportioned as to pack as closely as bricks, the faces and arrises fitting up to and protecting each other. These blocks, whilst producing hollow walls, obviate the loss of space during transit incidental to all systems of "hollow block" building; and a load of the blocks builds a greater amount of wall than a load of bricks.

Fig. 3 is a perspective sketch of a fence wall built of Z blocks and slabs, finished with a moulded coping; and fig. 4 is a plan of such a wall. Every alternate Z block, in this case, is reversed, which allows of the introduction of slabs stretching from rebate to rebate of the blocks. This combination of the Z block with slabs meets a want where an economical wall is desired.

Fig. 5 is a perspective view, showing the corner of a building in which the Z blocks are employed with quoin blocks for the angle; and fig. 6 is a plan of the same. For Z block building the tail end of one block fits into the rebate of the next, the course above breaking joint, the cross-tie or bonding piece stretching by this means from the center of the face of one block to the center of the face of the adjoining one (see "A," Fig. 5). Thorough bonding of the work is thus secured, and the strength of the wall equalized throughout. It will be noticed that when the Z blocks are used the joint in the facing comes opposite to and is backed up by a solid—that is, the cross-tie.

The following are some of the advantages claimed for this system, as compared with brickwork:

1. That there is a considerable saving in the quantity of

material employed, and consequently a corresponding saving in the cartage of such material.

2. That there is a large saving in mortar, not more than one-fourth of that used in ordinary brick walling being required, giving a corresponding saving in the cartage on this item.

3. As the workman (see Figs. 4 and 6) builds both faces of wall in setting a block, greater rapidity of work is secured, together with a saving of labor.

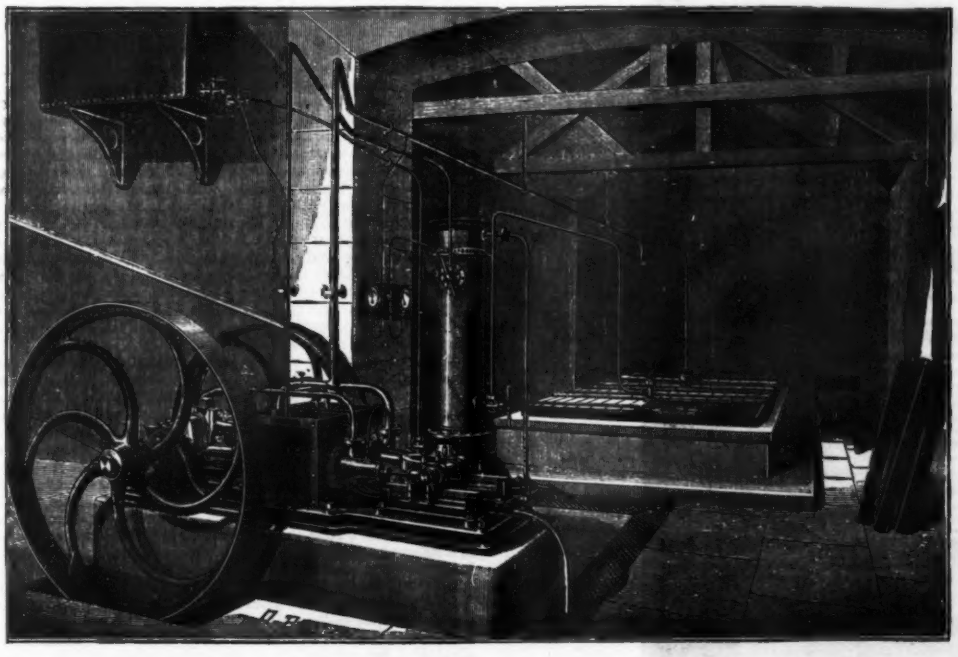
4. The **Z** blocks are equally available for the construction of hollow or solid walls, as the spaces may be filled in, if desired, with a rough kind of concrete.

5. By this system the walls are thoroughly bonded throughout.—*Building News.*

THE CHLORIDE OF METHYL ICE MACHINE.

IN SCIENTIFIC AMERICAN SUPPLEMENT, No. 172, page 2739, we gave a description of M. Camille Vincent's process for manufacturing chloride of methyl from the waste liquors (*vinasses*) left after the extraction of the sugar from the beetroot, and also description and figures of an apparatus, by means of which (chloride of methyl being used as the freezing agent) large masses of mercury might be solidified, and the temperature of any liquid reduced to —55° and maintained there for several hours. In that article it was stated that M. Vincent had lately constructed a much larger and more perfect and continuous form of freezing machine, in which, by means of an air pump and a forcing pump, the chloride of methyl is evaporated in the freezing machine, and again condensed in the cylinders; and that this enlarged form of apparatus would probably compete favorably with the ether and sulphurous acid freezing machines now in use. To-day we are able to lay before our readers a figure and description of M. Vincent's larger form of freezing apparatus.

The chloride of methyl freezing machine is composed of three principal parts: (1) a "freezer," where the cold is produced; (2) a pump, which forces the vapor of methyl chloride into the freezer, compresses it, and afterwards



M. VINCENT'S CHLORIDE OF METHYL ICE MACHINE.

forces it into a condenser, where it liquefies; (3) a condenser, or liquefier, serving to cool the vapor of the compressed methyl chloride and to cause its liquefaction, the liquefied product afterwards returning gradually into the freezer. The accompanying illustration gives a general view of one of these freezing machines, which is capable of producing from 225 to 1,100 pounds of ice per hour. The freezer, which in the engraving is to the right in the back part of the room and under the collection of cells holding the water to be frozen, is a horizontal tubular boiler containing the liquid chloride of methyl. An uncongealable solution of calcium chloride passes into the tubes of this apparatus, becomes cooled, and is afterward driven by the action of a helix around the cells which contain the water that is soon to be frozen. The vapor of methyl chloride produced in the freezer is aspirated through a long pipe, by means of a pump (seen to the left of the engraving), and is then compressed and directed through another pipe into the liquefier (seen between the two preceding apparatus), where the liquefaction is effected. The liquefier is composed essentially of a vertical tubular apparatus, within the tubes of which circulates the water which is to cool the compressed chloride of methyl forced around the tubes by the pump. The liquefied chloride returns to the freezer through a pipe provided at its lower part with a screw cock, which serves to regulate the outflow according to the speed of the machine. The compression of the vapor of the frigorific product is effected in these new machines with a degree of perfection that has never been hitherto reached in any of the ordinary ammonia, sulphurous acid, ether, or methyl ice machines, and the result is a greater yield of ice, and a saving of coal.

The compression pump has two cylinders of unequal diameters (as shown in the figure), and works after the fashion of "compound" machines, thus allowing all the known advantages of this system to be realized. The first piston, and the larger of the two, aspirates the methyl vapor and compresses it to just half the final quantity; the second cylinder then receives the compressed vapor, and its piston, after having doubled the pressure, forces it into the liquefier. The two compressing cylinders are arranged in a reservoir in which circulates a current of cold water; and, by this means, too great an elevation of temperature is avoided. The suction valves of the two pumps are moved mechanically, thus insuring a perfect regularity of action, as well as great precision. The pumps, which are placed upon the same frame, are arranged in such a way as to take up but little space; motion is communicated by a long connecting rod, actuated by a crank-shaft, which, in its turn, is actuated by the engine through an intervening pulley and belt. The operation of the freezing machine is indicated by two pressure-gauges, one connected with the liquefier and the other with the freezer. Normally, the pressure in the liquefier is only from 3 to 4 atmospheres, according to the temperature of the water used in refrigerating; and the degree of vacuum in the freezer varies from 0 to ½ an atmosphere according to the lowness of the temperature that it is desired to obtain. These methyl freezing machines offer a decided advantage over all others, for the following reasons: They need no oiling, since the chloride lubricates the pistons; they are not subject to the entrance of air, the product having a sufficient tension of vapor; the methyl chloride does not act upon the metals, and is in no wise decomposed by the working of the machine; the vapor, which has a sweet smell, does not inconvenience the workmen during repairs; finally, the working parts of the machine are very simple, thus allowing it to be afforded at a very reasonable price. To all this may be added that methyl chloride has now become an industrial product, the value of which is a half or a third that of other freezing agents in use. The new freezing machines will certainly have an important place in the ice-making industry, for they possess features of economy that have not before been attained.

IMPROVED PACKING PAPER.

A NOVEL kind of packing paper is manufactured by Foy Riviere in London.

It consists of a kind of common paper or thin card-board, to one side of which chips or small pieces of cork are fastened by means of glue or some other suitable material. The chips and pieces of cork are the waste from cork-cutting establishments. This improved paper is especially well adapted for packing glass and china ware, the cork side of the paper lying against the article and protecting it from sudden shocks and jars.—*Ackermann's Gewerbe Zeitung.*

PROPERTIES AND FUNCTIONS OF CHLOROPHYL.

A VERY important inquiry into the properties and functions of chlorophyl has just been made by Pringsheim,* whose results necessitate a great change in the current opinions on the nutrition and general physiology of plants. The main subject of the research is the influence upon chlorophyl, and upon the plant-cell generally, of concentrated sunlight.

Pringsheim's method is to place the plant under examination upon the stage of a microscope in the usual manner, and then to concentrate the sun's rays upon it by means of a heliostat and a lens of 60 mm. diameter. By this means an intense light can be brought to bear upon a very limited area of a plant, upon a single cell, or even upon a particular part of a cell, and the effect watched continuously and easily. This method of "microscopical photo-chemistry" has already, as we can see, yielded results of the highest importance.

The first effect on the living cell of the intense light is the complete destruction of the green coloring matter. This takes place in a few minutes, and by proper arrangement can be made so local as to affect only a single chlorophyl-grain, or a single patch in the diffused chlorophyl of an alga, all the rest remaining as green as before. This change is followed by the gradual dissolution of the remaining constituents of the cell; cyclosis ceases; protoplasmic filaments are broken up; the arrangement of the cell-contents is destroyed and their properties altered; the final result being the entire death and destruction of the cell, with the exception of its formed constituents, the cell-wall, starch grains, etc.

That these effects were in no way due to the heat of the sun's rays was shown by interposing in the path of the beam various colored media, when it was found that a blue solution, which shut off nearly the whole of the heat rays, had no effect in stopping the destructive action of the sunlight, while with a red solution, allowing eighty per cent. of the heat rays to pass, the cell and its chlorophyl remained quite unaltered.

Besides these experiments on the influences of rays of different refrangibility, Pringsheim tried the effect of surrounding the plant with atmospheres of various composition. The result arrived at was of great interest, namely, that the destructive effect of strong sunlight only takes place when the plant is surrounded with an atmosphere containing oxygen. No effect is produced either in hydrogen or in a mixture of hydrogen and carbonic acid, moreover, the presence of the latter gas is of no importance to the process, which takes place with equal rapidity in an atmosphere from which all the carbonic acid is removed.

From these experiments the important result is arrived at, that the destruction of chlorophyl by concentrated sunlight is a true process of combustion, and has no relation whatever to the decomposition of carbonic acid by the plant. And from the circumstance that the green coloring matter, once discharged from the chlorophyl-grain, cannot be restored, it is inferred that the process is not a normal but a pathological one.

The disintegration of the general cell-contents is evidently of the same nature. That it is independent of the destruction of the chlorophyl is evident, for it takes place in colorless cells, such as nettle-hairs. But as long as the chlorophyl remained unaltered, the protoplasm is also unaffected, so that the chlorophyl may be said to act as a protective covering to the protoplasm against the hurtful action of light, or, in other words, to diminish the intensity of the respiratory process. The absorptive property of chlorophyl on light, especially on the chemical rays, confers upon it, therefore, the power of regulating the respiration of the plant.

In connection with the disintegration of the cell-contents, the interesting observation was made that the colorless granules contained in the protoplasm diminished in number and disappeared during the earlier stages of the action of light, so that probably these bodies, the exact nature of which is unknown, are the most combustible parts of the cell-contents, and as such are used up in ordinary respiration.

But the constituent of the cell which shows the greatest degree of sensitiveness to light is a substance discovered by Pringsheim in the course of this inquiry, and named by him *hypochlorin* or *hypochromyl*. It is an oleaginous substance, occurring in the chlorophyl-grains, and may be extracted by placing portions of plants in weak hydrochloric acid for from twelve to twenty-four hours. It is then found to be in the form of minute semi-fluid drops, which gradually assume the form of indistinct crystalline scales, and, finally, of reddish-brown needles of a resinous nature. These crystals are, in all probability, formed by oxidation from the hypochlorin, as it occurs in the ground substance of the chlorophyl-grains.

Pringsheim considers that this remarkable substance is "the true primary assimilation-product of green plants," and that from it the starch and oil occurring in chlorophyl-grains are formed.—*Nineteenth Century.*

* "Ueber Lichtwirkung und Chlorophyll-Function in der Pflanze." Monats. d. k. Akad. d. Wiss. zu Berlin, July, 1879.

A NEW METHOD OF PREPARING SULPHURETED HYDROGEN.

By J. FLETCHER, F.C.S.

ANY mode by which the preparation of this useful gas can be rendered easier, and the unpleasantness of its manipulation diminished, will no doubt be welcomed by analysts: I therefore make no apology for submitting the results of some experiments made after reading a suggestion in some of the scientific journals, perhaps your own, but the name does not at the moment occur to me.

The plan is simply to fuse in a small glass flask sulphur and solid paraffin, leading the resulting gas by means of a perforated cork, India-rubber, and glass tube directly into the solution to be tested. The first gases are not sulphureted, but when the mixture has been thoroughly fused and mixed, the sulphureted hydrogen passes over abundantly.

The advantage of the process is that the moment the flame of the lamp is removed the evolution of gas ceases, and the little apparatus can be laid aside without fear of creating offensive smells. When used again, the gas passes at once when sufficiently heated.

A washing bottle seems unnecessary. I passed the gas for an hour through such a bottle, and the water, although most strongly impregnated with the gas, was fairly clear and limpid, showing only the usual appearances.

There are a few precautions to be taken. The mixture is inclined to bump when strongly heated, but a few pieces of broken tobacco-pipe shank prevent that. Care must be taken that when the lamp is removed, and the gas ceases to pass, none of the solution is sucked back into the bulb; it is very easily prevented. A very strong heat should not be applied, as then distillations would commence and the product condense in the tube.

I believe the process to be a simple, cleanly, and elegant substitute for the old methods, and particularly well suited for small and private laboratories. How it would work in large ones I would like to hear from those who are in a position to try it.—*Chemical News.*

DIGESTIVE FERMENT OF CARICA PAPAYA.

By A. WURTZ and E. BOUCHUT.

FROM the undecomposed juice of this tree the authors have obtained, by precipitation with alcohol, the ferment, in the form of an amorphous white powder, entirely soluble in water, and containing 10 per cent. of nitrogen. To this substance they have provisionally given the name of papaïn. It is distinguished from pepsin by the circumstance that it is capable of dissolving large quantities of fibrin not merely in presence of a small quantity of acid, but even in a neutral or slightly alkaline medium. It is doubtless analogous to the ferments secreted by carnivorous plants such as Nepenthes, Drosera, etc.

COMPRESSIBILITY OF GASES AT HIGH PRESSURES.

By E. H. AMAGAT.

IT appears very probable that when a gas submitted to increasing pressures, whether or not it has shown at first an augmentation in its compressibility, presents afterwards a decrease, it is always placed in conditions where it may, by pressure alone, pass gradually through all the intermediate conditions between the gaseous and the liquid state without liquefaction properly so-called. The decrease in the compressibility indicates then in general that the gas has reached a temperature higher than that of the critical point.

A NEW AND VERY POWERFUL ELECTRICAL OZONIZER.

AT the last meeting of the American Chemical Society, Prof. Leeds gave an account of an extended series of experiments, which had led to the construction of a new electrical ozonizer. The objects in view in these experiments were, in the first place, to convert as large a percentage of the air or oxygen operated upon into the form of ozone as possible; and secondly, to employ large volumes of the air thus ozonized. The first result had been obtained by Sir Benjamin Brodie and Prof. Von Babo, the former of whom had in one trial converted as much as 6·5 per cent. of a confined volume of oxygen into ozone. But the amounts of gas experimented upon by these two investigators were extremely small, from 100 to 300 c.c., and therefore, not capable of utilization for practical purposes. It was necessary to discover, if possible, some method of ozonizing to a maximum a large volume of oxygen flowing with a rapid current.

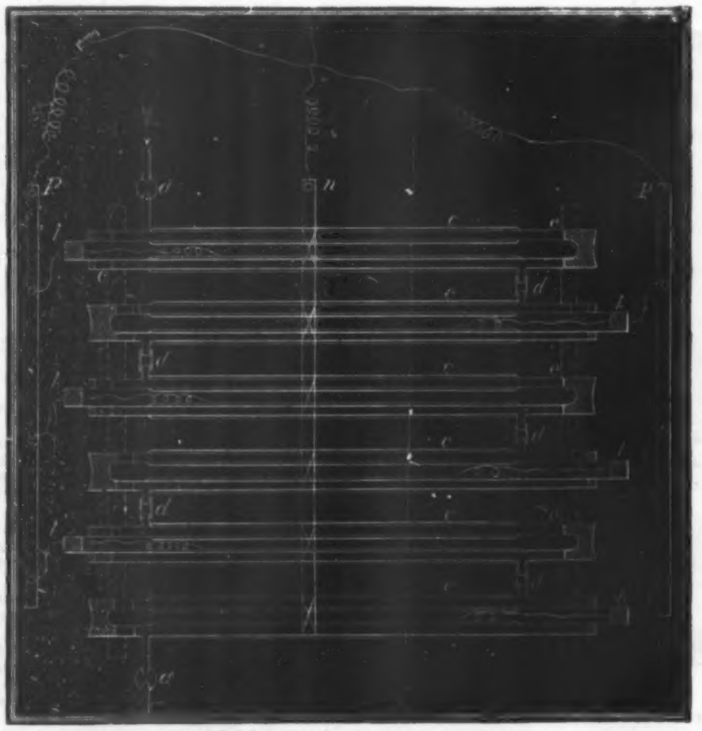
In preliminary experiments, the various forms of electrical ozonizers hitherto proposed were tried under uniform conditions, and the comparative results so obtained were noted. The electricity was derived from an induction coil, arranged to give about 60 sparks of 30 to 80 mm. in length per minute. Using such a coil, Houzeau's, Boillot's, Von Babo's, Wills', and different forms of Siemens' ozonizers were tried, and found inadequate to meet the wants above specified. The experiments, however, established the following principles of construction for an induction tube, giving satisfactory results: 1st. The amount of ozone increased with the intensity of the electrical charge upon the unit of surface. 2d. The smaller the interval between the electrified surface, the greater the amount of ozone produced. 3d. The quantity increased with the prolongation of the interval during which the air or oxygen was subjected to the electrical action up to a certain point when it arrived at a maximum, dependent upon the circumstances of the experiment.

These principles were finally embodied in the construction of an ozonizer, which may be termed an ozonizing battery, the arrangement of which will be best understood from the accompanying engraving. It is made up of a series of induction tubes, each tube being what might be called an ozonizing element. Each element is made of a tube of thin hard glass, 60 cm. long and 21 mm. inside diameter, with the inlet and outlet tubes 6 cm., from each extremity. The space between these two latter tubes is coated with tin foil. The inside tube is a little longer, one end being rounded; the other, after the interior has been coated with tin foil, is closed with a dry cork, through which the copper connecting-wire passes. The space between the rounded end of the inner tube and the outer tube is nearly filled by a ring of glass cut from a tube of suitable bore, and the space closed by dipping in molten sealing wax. In coupling the elements together, the exit tube of the first is joined to the inlet tube of the second by a wrapping of strips of muslin, which are bound by flower-wire and made gas-tight by a coating of molten paraffine applied with a brush.

Six of these elements are connected together and supported on a frame, constituting what we may term an ozonizing battery. One of these frames is fitted on above another, the end elements of the two batteries being suitably connected, and in this way, by repetition of similar parts, an induction tube of as great length as desired can be made and handled without inconvenience. Or the electrical charge can be divided between several ozonizing batteries, and the supply of oxygen as well, so that a number of currents of ozonized gas can be made use of at the same time. The first inlet tube of a battery and the last exit tube are made of parts of small sulphuric acid wash-bottles, by means of which the rubber or kerite connections with the other parts of the apparatus are protected from backward diffusion of the ozonized gas on the one hand, and a convenient attachment is made upon the other.

When 1 liter of oxygen was made to flow through the apparatus in half an hour, the spark length being 45 mm., the ozone obtained amounted, when 3 elements were used, to 22·8 mgrms.; when 6 elements were used, to 51·74 mgrms.; and when 12 elements were used, to 69·93 mgrms.

To obtain the best results with such a battery the following precautions should be observed: 1st. The connections at *dd* should preferably be made by grinding the end of one inlet tube into the corresponding exit tube, and the other joints should be made, not by sealing wax, but by fusing the glass. 2d. The number of elements used should be proportional to the strength of the coil, the maximum effect being obtained when the whole interior is luminous, but without sparks in a darkened room. 3d. The feeble inductorium should be replaced by one giving a large number, as well as a great length of sparks. 4th. The exterior foil should be covered with an outer enveloping tube of glass. 5th. The temperature of the ozonizing battery should be prevented from rising, by placing it within a refrigerating chamber and surrounding it by dry air kept at 0°.



aa. Small sulphuric acid wash-bottles. *bb.* Corks closed by melted sealing wax. *cc.* Outside coating of tin foil. *dd.* Connections of paraffined cotton cloth. *ee.* Rings of glass. PP. Copper strips connecting with inner coating and one pole of coil. *n.* Copper strip fastened to all the outer coatings and the other pole.

OZONIZING BATTERY.

KREATININ AND KREATIN.

By TH. WEYL.

IF a few c.c. of recent human urine are mixed in a test-tube with a few drops of a very dilute solution of sodium nitro-prusside, and if dilute soda-lye is then added drop by drop, a beautiful ruby-red color appears, which in a few minutes changes to an intense straw-yellow. This reaction seems characteristic of kreatinin. As kreatin is converted into kreatinin by boiling with dilute sulphuric acid, the reaction may serve also for the detection of this substance.

ALKALINE AMALGAMS.

By M. BERTHELOT.

THE author considers these amalgams as of great importance as the type of compounds resulting from the union of two solid constituents, such as the metallic alloys, the cryohydrates, the fats, butters, resins, etc. Are these products formed by the simple mixture of certain definite compounds, associated sometimes with each other, sometimes with one of the components in excess, in the manner of two powders mechanically mixed, and then brought into a coherent mass by external pressure? Or are the properties of each of these definite compounds modified more profoundly by the presence of an increasing dose of the other definite compound or by that of the component in excess, so that the properties of the total mass cannot be represented by the pure and simple sum of those of the two definite bodies supposed to be mixed? These questions the author endeavors to solve by thermo-chemical methods.

ASPIDO SPERMIN.

By G. FRAUDE.

ASPIDO SPERMIN, an alkaloid of the quebracho bark, crystallizes in small white prisms with strongly shining surfaces, readily soluble in alcohol and ether, but dissolving sparingly in water, and melting at 205° to 206°. The taste of the solutions resembles that of quinine.

VIRGINIA.

PROF. SONNENSCHEIN has given the somewhat singular name of "Virginia" to a substance which he has extracted from the residues of the distillation of petroleum. He describes it as a semi-transparent mass, yellowish, and fatty, and displaying, when heated, a blue fluorescence. It melts at 47°, and is partially soluble in ether.

HYDROCARBON FROM ROSIN OIL.

By W. KELBE.

IF the highest boiling products of the dry distillation of rosin are heated with sulphur to 200°, a crystalline body is obtained, consisting of 91·5 per cent. carbon and 8·5 hydrogen.

CONSUMPTION.

By CHARLES G. POLK, M.D.

TUBERCULAR CACHEXIA.

TUBERCULOSIS may be defined to be a dyscrasia or cachexia, constitutional in its extent, expressed in deficient vital force, and consequent upon impaired or deranged nerve influence, furnished by the nerve masses which immediately and especially preside over the nutritive and the respiratory apparatus, and not only produce abnormal manifestation of their functions, but lead to structural change and disintegration of tissue.

That these changes are produced primarily in the lymphatic glands, and by the elaboration of granules and corpuscles of a low standard of organismal endowment, which, being incapable of a higher evolution, retrograde through the various stages, awakening inflammation, ulceration, and disintegration of the organs involved. That in addition to infiltration of the organs by tuberculous or sickly leucocytes, the deranged or deficient nerve influence communicated from the medulla oblongata and base of the brain act directly upon the cell life of the organs themselves, modifying their nutrient powers, disqualifying them for the appropriation, from the blood, of their natural pabulum for the maintenance of their structural integrity, and unfitting them for withstanding the pathological processes, created by the presence of tubercle.

That deficient or deranged nerve influence emanating from the medulla oblongata, and the nerve masses which preside over the nutritive and respiratory apparatus, is the consequence of deficiency of phosphorus in those nerve masses; that the formula of phosphorus principally is the alkaloidal hypophosphite in association with glycerine, alkaline, and mineral bases.

The above view of the causation of tuberculosis, determined by the writer twenty years ago, has been confirmed by subsequent research and the results of experience. I may say that clinical observation, therapeutical demonstration, and chemical analysis, have so fully corroborated this ætiology and pathogenesis of this cachexia, that its accuracy seems well proven. In fact, this theory coincides very nearly with that advocated by Churchill, in 1855, and two years prior to my own researches, "that phosphorus exists in the animal organism in the form of hypophosphorous acid, and its deficiency is the determining cause of tubercular phthisis. To sustain this hypothesis and the therapeutical treatment based on it, is the object of this paper.

The phenomena presented from the earliest manifestation of modified health, through the different stages it presents, until the final termination of tubercular disease, it seems to me, sustain the conclusion advanced in this definition of the malady, and the explanation of its causation. It embraces within its circle the hypothesis of the various interpreters of the earliest lesions presented, and enables the pathologist to link together the chain of aberrations so as to constitute a complete whole, and appear as the sequence of a common cause. Thus we find, as one of the earliest aberrations, the patient, without any visible cause, loses weight and strength, being exhausted by exertion which he had previously borne without fatigue. As this shrinkage and loss of flesh often occurs while the appetite is good and gastric digestion seems unimpaired, the cause must be sought in the deficiency of the vital processes by which food is elaborated into blood. That there is an interference with the formation of normal chyle by an acid condition of the small intestines; that the pancreatic juice is either deficient in quantity or neutralized by the acid, as pointed out by Bennett; that these lesions are the proximate consequence of a deficiency of the phosphatic nutrient of the brain and nervous system in the nerve masses, from which the eighth pair of nerves derive their sentient, nutrient, and motor functions; that this phosphatic nutrient of the brain—zooline—is a union of a nitrogenous glycerite with a sui-generis form of hypophosphorous acid, in a nascent condition; that as it emerges from this nascent form it sets in motion the entire machinery of life, and constitutes the motor power of animal existence; and that upon its adequate supply and normal formula are reposed the display of the physiological and pathological manifestations of the animal functions. Consequently, a deficiency of this alkaloidal hypophosphite in the nerve masses which preside over nutrition and respiration must lead to deranged functions, and finally to structural change in the organs which are concerned in these functions.

The above view of the causation of tuberculosis, and the above statement of the processes by which its consequences are wrought, were determined by me during the summer of 1857. I demonstrated the accuracy of these by chemical analyses of the brain and other tissues of those dead from consumption, and confirmed the scientific deductions advanced by Churchill, in 1855. I, however, advanced the idea in a lecture before the Milford (Del.) Literary Society, March, 1855, on the relation of the base of the brain to vital force and to diseases growing out of deficient vital force, and contended that consumption had its prime factor in the nerve masses which preside over digestion and respiration. Still, we must yield the authorship of the phosphorus theory of consumption to Churchill, of Paris.

I design in this paper to prove the accuracy of these conclusions by scientific deductions, and to support these scientific deductions by an accurate chemical record. The phenomenon of tuberculosis is the language of a deficient vital force, and to a large extent the expression of a feeble physical organization. Although Louis and Laennec long ago recognized a tuberculous diathesis, their descriptions were marked with inaccuracy and their value ignored by the medical world; the views of Buhl, Virchow, Addison, and Niemeyer having well-nigh overthrown them, and substituted in their stead the septicæmic theory of tuberculosis—that tuberculosis is but the consequence of a virus, generated in the caseous metamorphosis of inflammatory products, and is in no manner concerned in the primary morbid conditions.

In my investigations of the morbid anatomy of tuberculosis I have found many appearances which seem to corroborate the previous declaration of Addison, that tubercle is not a universal accompaniment of phthisis, and that autopsies of those dead with phthisis frequently do not reveal a trace of tubercle. By investigating the previous history of such cases I invariably found that all these cases had their beginning in an attack of pneumonia, bronchitis, or pleurisy, which, being neglected or uncured, had assumed a chronic form of capillary bronchitis, terminating in lung hepatization, tyrosis, ulceration, and the ultimate destruction of lung tissue.

I included these cases under the title of Chronic Pneumonia, in my thesis to the Faculty of the University of New York, 1858, and declared the necessity of drawing a line of demarkation between them and those which began insidi

ously and slowly progressed to a fully expressed pulmonary lesion. The differences I have since regarded as sufficiently marked to constitute an entirely different malady in its incipiency, and to preserve individual characters through its entire course.

But in investigating the lesions presented several difficulties are encountered. Tubercles, in their mere presence, do not inflict formidable damage; lung disintegration is largely produced by the changes they undergo into cheesy masses, and the irritation these cheesy masses excite. Pneumonic phthisis also produces its lesions in a similar manner. It may also be noted that in the metamorphosis of tubercles into cheesy masses the tubercles very frequently awaken the same type of inflammatory action as that displayed in the primary pneumonia, so that consequently the very class of lesions found in the tubercular will be found in the non-tubercular cases, minus the presence of tubercles. But even this distinction is not so easily made, unless we limit the term tubercle to the over-growth and morbid changes in adenoid tissue, from the intrusion or generation of molecules, nuclei, granules, or leucocytes of a morbid character, which retrograde from miliary to yellow tubercles, awakening inflammation and ulceration (and I think this limitation should be placed upon the term tubercle). It is very difficult to discriminate between the granules, nuclei, and leucocytes thus lodged, and the exudation of these into the alveoli as the consequences of inflammation.

This difficulty involves the diagnosis in obscurity, but I believe the history of the case, including the manner of invasion, presence or absence of duodenal dyspepsia, family history, physical conformation, and the presence or absence of those habits and conditions which develop tuberculosis *de novo*, will almost invariably lead to a correct diagnosis. Excluding, then, those cases of phthisis in which there is no hereditary predisposition, no violation of physical conditions, or moral causes present, as sexual excesses, brain and nerve exhaustion, or naturally weak respiratory apparatus, the circle is limited to the class of cases which have their prime factor in a deficiency of phosphorus in the system, the class of cases benefited by the assimilable oxides of phosphorus, the class of cases which really present the tuberculosis diathesis.

Let us examine the characteristics of a tubercular diathesis. If there be one unerring indication of a tuberculosis constitution it is marked by Powel's "Life Line." A line drawn from the external angle of the eye to the tuberosity of the occiput will indicate by its own elevation over the external meatus the amount of vital capacity of the person. In those strongly predisposed to tuberculosis the distance will often not exceed half an inch over the external meatus auditorius. This line will always prove an index of the natural vigor of a person. Of course it will not indicate vital depreciation produced by excesses, or causes which have only been recently brought to bear. While causes operating during childhood may produce this conformation, it cannot be produced by any circumstance in the adult.

While a low life line is pathognomonic of a feeble organism, incapable of resisting the inroads of any morbific influence, a very extended observation has convinced me that it is the only conformation in which any importance can be reposed. The chicken breast has not the value usually attributed to it. The writer has noticed it in a very small per cent. of consumptives of the tuberculous kind, and really more frequently in the victims of epithelial pneumonia. As tuberculosis is not essentially a lung disease, but the result of mal-nutrition, it is scarcely rational to hope to find the pathognomonic conformation in the lungs, but rather in the base of the brain and in the organs immediately concerned in nutrition.

As I have already said, I have found that a considerable portion of the cases included under the name phthisis pulmonalis, are nothing else but cases of epithelial pneumonia, in the lesions of which tubercules are not necessarily concerned, and in which they are not usually found. In my medical thesis I claimed this as an original idea of my own, but then was unaware of the previously asserted doctrines of Buhl and Addison on this point. I, however, have asserted since 1857 that tuberculosis, epithelial pneumonia, and artisan's phthisis are three distinct entities; that no one of them necessarily produces the other; that artisan's phthisis is the immediate consequence of inhaling particles of stone, steel, or other dust; and this dust finding its way to the bronchioles, excites irritation of a subdued character, which usually failing to awaken inflammation, excites hepatization; the hepatized lung usually takes on caseous degeneration, lung structure is destroyed, and vomicæ are formed. Epithelial pneumonia may present the ordinary phenomena of a case of acute pneumonia and verge into a chronic form, or it may begin in a sub-acute form and thus continue; the air vesicles being filled up with the debris of epithelial cells excite ulceration, and thus destroy lung tissue. Tuberculosis, on the other hand, is a disease of disordered nutrition, as I have proved, and inflammation is not immediately concerned in its production. The fact must, however, be admitted that inflammation, as well as any other cause which lowers the vital standard, may awaken the processes of tuberculization on the one hand, and on the other that caseous tubercules are very liable to awaken pneumonia; yet the fact seems evident, to my mind, that the hypothesis of Addison, Buhl, and Niemeyer are founded in error, and the only escape from the confusion morbid anatomy creates is to recognize at least three distinct diseases under the name of phthisis pulmonalis—epithelial pneumonia, pulmonary sclerosis, and tubercular phthisis.

Confining ourselves to the consideration of the latter malady to the exclusion of the other forms, much of the difficulty surrounding the subject at once vanishes.

With this distinction I will consider the hygienic and therapeutical measures which in my experience have proved the most efficacious.

In assuming charge of a phthisical patient several points suggest themselves as to his management.

The hereditary predisposition is inquired into, and the family history sought out. Formerly this was considered of great moment; but while we cannot yet ignore entirely its importance, research has demonstrated that a large per cent. of tuberculosis is acquired by the individual, and the acquired tuberculosis does not differ from the inherited disease. Inquiring into these causes, we find that insufficient food and clothing, impure air, damp, chilly residences, may create the disease. If these be causes adequate in themselves to create the disease *de novo*, they certainly should not continue to be exerted upon the individual already impressed; consequently if these causes be still in operation, they must be removed, or else they will neutralize all the results which would otherwise follow the employment of therapeutical agents. Sedentary occupations must be abandoned; the duties of the counting-room are antagonistic, so these must be laid aside and the fresh air of the country sought. But even there damp, unhealthy locations must be avoided, and elevated position free from miasma selected.

The indiscriminate sending of consumptives to such a place as Cape May is nothing but professional murder; the sedative influence upon the irritated lungs and larynx, I am well aware, in some cases seem to give a temporary advantage, but the lessened respiration which the damp air, loaded with salines, induces, favors the exudation of devitalized protoplasms and cells into the apex of the lung, so that under the flag of truce the enemy makes continual inroads into the vital forces and prepares for more thorough devastation. High, dry locations, with comfortable surroundings, act the very reverse; rarefied air demands deep and full inspirations, and these force the air to every portion of the lungs, and thus obviate the condition favorable to tubercular deposit.

The Delaware Water Gap and Schooley's Mountain are admirable locations for summer residences. Tuberculous persons going to either almost invariably receive benefit that is in a large measure permanent. As a winter residence I do not think there is another spot on the globe where every advantage of a good location, dry, pure air, good water, pine forests, good diet, are so perfectly presented as at Aiken, S. C. Asheville, North Carolina, is an admirable residence during the spring, summer, and autumn.

But if the victim of phthisis cannot enjoy these advantages, he should be kept as much as possible in the open air, carriage riding, horseback riding, walking, gunning, fishing, or even an out-door occupation must be required. Anything to get the patient out of the house. Out-door exercise is of the first importance. Airy sleeping apartments must not be overlooked. While MacCormac went too far in attributing every case of phthisis to breathing air which had been previously breathed, there is no doubt that crowded sleeping apartments are really hot beds of tuberculosis. The baneful consequences of these is aggravated if the ventilation be imperfect. Not more than two persons should occupy a room of ordinary size, and these as a rule should occupy separate beds.

The diet should be rich and nutritious. Food abounding in the nitrogenous phosphorus compounds should be eaten as freely as the digestive organs can digest and assimilate. Eggs are very rich in these, and I have found them one of the very best articles of food possible to give. The formula in which the hypophosphite exists is principally in the combination with oil, glycerine, and albumen.

Oysters are also nutritious, containing the hypophosphites principally in their alkaline association.

Onions contain the hypophosphites in a large amount, and if eaten raw afford a good supply of phosphorus principles. Fish, occasionally eaten, answer a good purpose. Milk is of especial value, and cannot be properly omitted from the diet table of the consumptive. Beefsteaks, animal soups, and saccharine vegetables must also be eaten.

Medical Treatment.—Of the many hundred remedies which have been brought forth as specifics but few are now even employed at all. These few are cod liver oil, extract of malt, the bark of the wild cherry, and the hypophosphites.

Cod liver oil yet retains the confidence of the largest number of the medical profession. The results of an extended trial has decided that it delays the progress of the disease, keeps up the flesh, prevents emaciation, generally prolongs life, and occasionally cures. The disagreeable odor and nauseous taste are, however, very objectionable, and often so sicken and disgust the patient as to prevent its use.

Maltine, although a younger applicant for professional favor, is fast winning a high place as a remedial agent. It has been quite extensively used in this country and in Europe in phthisis, in place of cod liver oil, and the general verdict is that it meets every indication; and being remarkably free from all objections, pleasant in taste and odor, is rapidly superseding the oil in medical practice. If the oil be employed at all, its administration will be very much facilitated by mixing it with equal portions of the maltine.

The writer has used the emulsion of maltine and cod liver oil in twenty cases, with very satisfactory results. A more perfect emulsion of cod liver oil could not be desired. I believe that if extensively tried it will find almost universal favor. This maltine, being a combination of the malt of barley, wheat, and oats, seems to blend in a single preparation great advantages over most of the malt preparations, containing, as it does, the nitrogenous matter, the phosphates, and the fatty and glutinous, or muscular elements. My success with maltine has taught me to appreciate it highly, as I do all the reliable preparations of malt. Malt or maltine may also be combined with hops, iron, and quinia, the hypophosphites, or with pepsin or pancreatine.

The hypophosphites are the discovery of Dr. Churchill, of Paris. As already stated, he made and began using the hypophosphite of lime and soda in 1855, on the hypothesis that pulmonary consumption had its prime factor in deficiency of the oleo and glycero-nitrogenous hypophosphites in the system, and in July, 1857, reported the result in thirty-four cases to the Academy of Medicine of Paris. During the months of June and July, 1857, I also determined by chemical analysis that tubercular phthisis had its prime factor in a deficiency of the hypophosphites in the nerve masses from which the eighth pair of nerves emerge. Churchill introduced into medical practice laboratory made hypophosphites. Two years later than Churchill the writer isolated the hypophosphites from animal brain, and employed them as a remedial agent until he became connected with the Federal Army about the beginning of the rebellion.

Churchill held the view that the phosphatic nutrient of the brain is hypophosphorous acid, that phthisis was caused by a deficiency of this acid, and the remedy is the hypophosphites of lime and sodium, in 1855, or two years prior to the researches of the writer.

The value of Churchill's hypophosphites in phthisis may be said to be undetermined. Some report excellent results following their use, while others have not witnessed the slightest advantage. When it is considered that several different maladies have been included under the name of phthisis pulmonalis the different results are explainable. I believe in tubercular phthisis they will be almost always found to be useful. Such has been my experience in hundreds of cases.

But while my confidence in Churchill's remedy is great, I believe isolated organic hypophosphites are more assimilable, active, and efficacious than those prepared from phosphorus. Dr. Wiley's paper in the Louisville *Medical News* (June 2, 1877); Dr. Ashmead, in the Detroit *Medical Journal*, and Dr. Williamson, in the Cincinnati *Medical News*, corroborate this view. Dr. Geddings, of the Aiken (S. C.) *Consumptive Sanitarium*, has used in thirty cases isolated phosphorus compounds, and found very satisfactory results to accrue. The preparation I most prefer is the "glycerite of kephaline," or brain and wheat hypophosphites isolated by bisulphide of carbon, terchloride of carbon, chloroform, and alcohol.

FORMULA.	PARTS.
Isolated organic hypophosphite of calcium ...	8
" " " sodium ..	6
" " " potassium ..	5
" " " ammonium.	8
" " " magnesium.	3
Glycero hypophosphorous acid...............	5
Free organic hypophosphorous acid....	5
Glycerine (chemically pure)	60

The dose of this preparation is from ten to fifteen drops. It may be given in water, simple elixir, Curacoa cordial, or maltine. The following is an excellent combination:

Maltine............ .... ℥ xv.
Glycerite of kephaline .... fl. ʒ xij.

M. S. Take dessertspoonful three times daily.

The writer recommends the above as giving a very high degree of success in a large per cent. of genuine tuberculosis. When the maltine cannot be procured a similar amount of malt extract may be used.

The cough is the symptom which annoys the consumptive more than any other, but nauseating expectorants are injurious, and morphia interferes with the digestive function. The fir balsams seem to be of more advantage than any other class of pulmonary remedies, and several firms have prepared some pharmaceutical combinations of these, which I have found convenient and profitable to use. For the last twenty months I have been using the Yerba Santa in those cases which take the character of a pneumonia of a chronic type, and have learned to esteem it very highly. The glycerole of yerbine compound is a convenient combination for country practitioners, who often have not the time or opportunity for extemporaneous pharmacy.

For night sweats I rely on a pill containing one grain of the extract of camomile, one grain of the oxide of zinc, two grains of gallic acid, and a sixtieth of a grain of atropia. Experience has taught me to rely on this combination in preference to any other. For diarrhea, I give sulphate of zinc and opium. For hemorrhage, five grains of the acetate of lead and half a grain of opium every hour until relieved, or in case the stomach will not tolerate this, the well-known combination of Dobell.

Infantile phthisis requires some modification of treatment. I have found cod liver oil, lactophosphate of lime, and wheat phosphates the best agents.—*Physician and Pharmacist.*

ACTION OF DRUGS ON THE SECRETION OF BILE.

A REPRINT of the several memoirs read before the Royal Society of Edinburgh, by Professor Rutherford, gives us in a collected form the results of his long-continued and carefully-conducted researches on the physiological actions of drugs on the secretion of bile. There is perhaps no organ of the body the affections of which are spoken of with greater confidence and treated with more rashness than those of the liver, whilst at the same time there is none as to which our ignorance of the circumstances which modify its functional activity and of the physiological action of its secretion is more profound. It is not uncommon to hear even members of the profession account for headache or depression of spirits, or some temporary impairment of vision or of hearing, by the statement that their liver is out of order, or that they are suffering from an attack of the liver without being able to give any intelligible explanation of the expressions they have used; whilst remedies of all kinds, on the strength of their purgative action, have been and still are administered, with the view of unloading the liver, with but little evidence in support of their supposed influence. As Professor Rutherford observes, the physician has had no difficulty in determining when a substance excites the sweat-glands, the salivary glands, or the kidneys, but as regards the liver, he has been so much embarrassed that although substances supposed to increase the discharge of bile—the so-called cholagogues—have been administered to man for over two thousand years, there has always been much uncertainty as to those which are really to be regarded as cholagogues, and even in the case of any agent which increases the discharge of bile, it has been quite uncertain whether this effect is due to a stimulation of the bile-secreting or of the bile-expelling mechanism.

Thanks to the labors of Kiernan, and a host of microscopical observers since his time, the anatomical arrangements of the very complex structure of the liver are now fairly understood, though there are still some disputed points, especially in regard to the precise mode of origin of the biliary ducts. Our knowledge, again, of the characters of the bile, the chief and most obvious result of the functional activity of the gland, is tolerably accurate; though if we turn to any of the works on physiology it will be seen that, whilst it is believed, on account of the place where the secretion is poured into the alimentary tract, to play an important part in the function of digestion, scarcely any satisfactory information has been acquired in respect of its digestive powers. We need hardly remind our readers how inadequate is our knowledge of the glycogenic function of the liver. Glycogen itself has, indeed, been thoroughly investigated, and its composition is accurately known; but its source, the mode of its formation, the amount that is formed, and the uses to which it is applied in the economy, are all obscure and unsettled points of physiology.

But if these difficulties and uncertainties exist in reference to the anatomical and physiological peculiarities of the liver, how much greater are the difficulties and uncertainties that meet us on every side in studying the action of drugs on the liver. This has been so well argued by Professor Rutherford that we may quote his words: "Admitting that the clinical observer has supplied valuable information regarding the power of various substances to increase the amount of bile in the dejections, the manner in which this result is brought about is in the highest degree uncertain. On the one hand, it might be occasioned by stimulation of the hepatic secreting apparatus, or, on the other, by stimulation of the muscular fibers of the gall-bladder and larger bile-ducts—to wit, the bile-expelling apparatus; or it may be occasioned by removing a catarrhal or congested state of the orifice of the common bile-duct, or of the general extent of the larger bile-ducts, or by removing from the intestine substances which had been passing therefrom into the portal vein, and depressing the action of the hepatic cells; or, lastly, by stimulating the intestinal glands, and thus producing drainage of the system whereby the 'loaded' liver might possibly be relieved. Any one or all of these causes may be in operation, and it can only be repeated that such know-

ledge as has hitherto been possessed and acted on rests upon a singularly uncertain basis."

Professor Rutherford found the dog to be, on various grounds, the animal by far the best adapted for experiment, especially because the results at which he has arrived are in complete harmony with every perfectly ascertained fact regarding the actions of medicinal agents on the human liver, and prove that the liver of this animal is affected in the same sense, though it may not be in the same degree, by substances that act on the human liver. In almost all instances the animal was fed for the last time in the afternoon, and was then allowed to fast till the following morning, when the stomach was completely empty. The introduction of a small dose of curara prevented irregular muscular movements, and avoided any possible disturbing influence these might have on the activity of the secretion. It was necessary, of course, to maintain artificial respiration. Nearly all the drugs were injected into the duodenum In a few instances the bile was analyzed, but valuable as the information would have been, if this had been adopted in every instance, it was found to be so laborious that it was unwillingly given up. It is obvious, however, that a knowledge of the composition of the bile secreted under the influence of different drugs would be of still greater value than that of the quantity alone.

The method adopted by Röhrig of counting the drops of bile as they were secreted was abandoned for the more satisfactory and less laborious method of allowing the bile to flow into a fine cubic centimeter measure and recording the quantity secreted every quarter of an hour.

It is impossible even to mention the various drugs which have been made the subject of experiments, and which are at least fifty in number; but one or two may be selected as of general interest, and amongst them calomel occupies the foremost place. The action of this drug has been very generally regarded as that of a stimulant to the liver, leading to an increase in the quantity of bile—a view that was founded in part on its purgative action, and in part on the green tint that it frequently confers upon the fæces of children to whom it has been administered. Professor Rutherford's experiments show clearly that this is incorrect, and that whilst calomel, in doses of ten grains, five grains, or two grains, several times repeated, when placed, without bile, in the duodenum of a fasting dog, produces a purgative effect, varying with the dose, it, so far from increasing the secretion of bile, usually diminishes the secretion, just as when any other substance that is not a hepatic stimulant—*e. g.*, magnesium sulphate—is administered. No difference is observed in the effect even when calomel is mixed with bile and then introduced into the duodenum. Calomel, then, has no power to increase the biliary secretion; but it is worthy of note that mercuric chloride or corrosive sublimate is a powerful hepatic stimulant in the dog, and the question immediately arises whether calomel may not be in part converted into corrosive sublimate by the action of the acid gastric juice. To this question, however, Professor Rutherford is enabled to give a very decided negative answer, and the purgative action of calomel must therefore be attributed to its stimulant action on the glands of the intestine. The important practical application follows, that if it be required both to excite the activity of the intestinal glands and to augment the secretion of bile, calomel, with a small admixture of corrosive sublimate, should be employed. Podophyllin, aloes, colchicum, ipecacuanha, colocynth, dilute nitric acid, sodium benzoate, and salicylate, are amongst the more powerful hepatic stimulants, though they act in various ways; some, like podophyllin, apparently affecting the intestinal glands equally with the liver: others, like ipecacuanha, affecting the liver almost exclusively; and there are many purgatives which owe their drastic power, not to their action on the liver, but to their action on the intestinal glands, as in the case of scammony, Rochelle salt, and manganese sulphate.

We commend Professor Rutherford's experimental researches to the profession, as constituting the foundation of a rational treatment of hepatic diseases, and feel satisfied that they will be carefully consulted by all who desire to prescribe drugs in these affections which shall fulfill the indications required.—*London Lancet.*

[Continued from SUPPLEMENT, No. 201.]

THE ROLE OF PATHOLOGICAL ANATOMY.

Inaugural Address of PROF. J. COHNHEIM.

Translated for the *Scientific American.*

II.

THE charm of anatomo-pathological studies attaches to everything else. If it were only a question of obtaining by the anatomo-pathological method, a rigorous determination of the disease, we would scarcely have recourse to this naturally disagreeable method in those cases where observation of the living patient did not leave the least doubt. Admitting, moreover, that clinical teaching has the greatest interest in verifying the diagnosis made during life and in explaining the clinical symptoms by the results of the autopsy, would there be a real necessity for the great apparatus with which pathological anatomy to-day surrounds itself on every side? In place of the vast and costly pathological institutions, in my opinion, a simple autopsy room, spacious and well lighted like that possessed by all the city hospitals, would suffice; in place of the special professor, with his assistants and his sub-assistants, a simple prosector would be enough, who would perhaps better be attached in the position of assistant to the clinical professor. Moreover, who would ever have the idea of making an autopsy on a man carried to the hospital dying, or already dead, and who consequently had not been the subject of any clinical observation? Well, on the contrary, the anatomo-pathologist does not make these distinctions in the choice of the cadaver that he examines; and the cause of this is that the role of pathological anatomy is far from being exhausted when it has established exactly and described the macroscopical and microscopical results of the autopsy. *For pathological anatomy is not a descriptive science in the same sense as normal anatomy.* The latter encounters, as well, it is well known, varieties of every kind; nevertheless I can describe the larynx or the liver, or any bone whatever, of an adult man with sufficient precision and clearness that even an outsider may recognize the organ that is in question. But of the typhoid or dysenteric intestine, of the inflamed lung, of the cancerous liver, I may sketch to you a series of descriptions completely different one from the other, but at the same time all exact and correct. In these conditions you will acknowledge that the establishment and description of the necroscopic results have isolatedly little value: they only have their value when, at the same time, we always endeavor to *explain* these results.

Indeed, if the human organism is not simply an agglomeration of any kind whatever of parts constituted indifferently in such or such a manner, if, on the contrary, its structure is regulated by determined laws, all deviation from these laws requires an explanation. What must be explained is, in the first place, the *cause* of the deviation. For, from the general principles of biology, this axiom immediately and necessarily results, that any disease, any pathological state of an organ of whatever nature, can not be produced *without cause*, or, as they say, *spontaneously*. The healthy human germ always develops, as long as external circumstances do not intervene to trouble it, into a healthy and normal individual, who remains such by reason of his physiological organization as long as he is not exposed to morbific agents which this organization can not overcome. When then, on examining a cadaver, we find an abnormal peculiarity of any organ whatever, we conclude, without hesitation, whether the natural disposition of the individual was originally vicious, or whether from a certain moment a morbific cause had acted upon him; whether it was either of the two categories of diseases to which we apply the denominations, congenital diseases and acquired diseases. In truth, it is not with perfect exactitude, nor in consequence of a just right. For, on one hand, physicians have known for a long time diseases most specially hereditary, and belonging indubitably to a vicious predisposition which, nevertheless, only declare themselves years, and even tens of years, after birth; for example, divers species of tumors, and of tuberculoses, etc.; and, on the other hand, when a child whose mother had been attacked by smallpox during pregnancy, is born with a variolous eruption, or when, following an intra-uterine inflammation of the cardiac valves, it comes into the world with a pulmonary stenosis, neither the variola nor the cardiac lesion has the least relation with the embryonic predisposition of the child. The external criterion furnished by the date of the appearance of the disease is then insufficient to determine the etiology. Is pathological anatomy generally capable of giving information about the cause of a disease or a lesion, that is to say, about anything which ought necessarily to have *preceded* the disease? At first sight it seems astonishing, but nevertheless it is true, that the greatest successes of the anatomical method have been obtained precisely in the field of etiology. For a long time etiology has been partly determined, with the aid of statistics, from the results of anatomical researches. Thanks to this procedure, it has been demonstrated that certain visceral anomalies depend on constitutional syphilis, that certain diseases of the meninges and of the liver have their source in the inveterate love of strong liquors; that some very remarkable alterations of the liver, the kidneys, etc., are the effect of acute phosphorus poisoning. We can not certainly disregard the fact that we have thus arrived at a very high degree of probability relative to the causes of diseases. However, on all sides we have recently endeavored to discover these causes directly and immediately with the sole aid of anatomical information. These efforts have been successful because, by reason of its nature, the animal organism only reacts under morbid accidents against an influence of whatever nature, in so far as it is present and acting in it. It is thus that *trichinæ* have been shown to be the efficient immediate cause of a general disease until then enigmatical; it is thus—a thing much more significant—that there have been established in splenic blood, in relapsing fever, in malignant endocarditis, in grave traumatisms, the constant presence in the blood or in the tissues, of organisms much less elevated but just as characteristic. In the whole group, so considerable, of infectious diseases, the *contagium animatum* of the ancient authors has ceased today to be a hypothesis, and it is with justice that science now asks of pathologists to discover in every infectious disease the parasitic organisms that produce it. It is no longer agreed where to place the limits of the class of infectious diseases. Certain authors accord an infectious character even to malignant tumors, and others do not hesitate to refer to infection every catarrh, all that has been ascribed to catching cold. I have so much the less to discuss here the value of these views, as it is always a question of more or less; for if hygiene, cultivated to-day with so much zeal, has ever arrived not only at a knowledge of all the agents of infection, but even at their removal or rendering them inoffensive, the duration of human life does not seem longer, nor the diseases, on that account, suppressed. It would be perhaps an enterprise eternally vain to attempt to penetrate, by the anatomical method, the real causes of the enfeeblement due to the progress of age, or of the non-infectious diseases that menace our health; for example, gout, diabetes, and above all the chronic diseases of the nervous system. Scarcely can we know merely the anatomical signs of most of them. However, this immense chasm does not constitute the chief defect of the anatomical method as applied to the search for causes; it is much deeper and is situated in the very essence of this method, for never, it is evident, can it furnish an absolutely convincing proof of the relations of causality; this proof is only sure to us if we can, with the aid of the supposed causes, reproduce at will the corresponding effect, that is to say, a determined disease. In other words, the surest basis of etiology is not the *anatomical method*, but the *experimental method*. We only ceased to question and contest the relation of cause and effect between phosphorus poisoning and the organic lesions pointed out above, on the day that we could produce the same lesions in dogs and rabbits by administering phosphorus to them; and to-day a number of savants are at work in different laboratories trying to demonstrate experimentally that certain infectious diseases depend on the bacteria that characterize them, a demonstration which, up to the present, has only been truly made in an absolute and irrefutable manner for splenic blood.

But of whatever advantage the knowledge of the causes of diseases may be to us, whoever has taken the trouble to comprehend the concatenation of pathological facts, may well content himself for his pains. For the hygienist who wishes above all to prevent the disease, it may suffice, but to the physician, called only when there is no more time to prevent, and above all, to the pathologist who has no practical aim, there must be something more; *they wish to apprehend the intimate connection between the cause and the effect*; they wish to comprehend *how and by what mechanism* the alterations are produced, by which the organism reacts against the morbid causes. Inasmuch as we have not reached this point, we can not, in my opinion, say we are scientifically satisfied. To know certain organic lesions to be the effect of phosphorus poisoning is not in the least, to my mind, either to resolve the enigma, or to diminish the need of explanation; that, on the contrary, has much increased.

But, will you ask, does the anatomical method permit us to establish the connection between what has occurred and the morbid phenomena, what we call, in a word, the pathogeny? There was a time when the pathogeny served to point out the anatomy, especially at the beginning of the intervention of the microscope in the examination of pathological objects. Then rose up, under the active impress of innumerable details that disclosed themselves to the astonished eye, a number of theories that to-day appear to us difficult to comprehend. At this primitive epoch, singular illusions were made under the power of the microscope. Anatomy can only have for its object the actual state of the organs, and those of their modes of transformation that we can study by observing the most complete series possible of the successive states through which these organs pass, that is to say, the processes of development and of growth. Beyond this there has never been obscurity for the pathologists of former times; and still, it is to take in its proper sense, the figurative expression of *stadium incrementi et decrementi*, or that of development and growth of a disease. These are the expressions very often used: inflammation of the lung is developed, the cardiac lesion grows greater, the dropsy increases; but is there anything in common between this method of speaking and the true process of development and growth of scientific anatomy? It is not because there is not also in pathology a process of this last kind. On the contrary, the entire group of true vegetations, a great part of the vices of conformation, and all the regenerations range themselves under this category, and it is impossible to comprehend these processes, so important, otherwise than by studying with the greatest care their anatomical details.

But these processes excepted, and perhaps also some other analogous ones, we have no more to do in pathology, absolutely as in physiology, than with the chemical or physical modifications in the state of the tissues or the apparatus, and the modifications of functions that result. When you see the cells of an organ filled with fat, or its tissue impregnated with calcareous salts, or the articular surfaces encrusted with urates or ordinary protoplasmic albumen, having small granulations of a dull aspect, replaced by a shining substance like wax and with unusual reactions, may the explanation of these alterations be sought elsewhere than in the study of their chemical conditions? Or yet again, when in the tissue of a part of the body, instead of the normal lymph in small quantity we find a large amount of exudation, hypostatic or even inflammatory, how can we arrive at a comprehension otherwise than by studying the movement of the blood and of the lymph of that part, the tension and rapidity of the current, the permeability of the vascular walls, etc.? The most exact microscopical examination of the blood does not give, we well know, the least indication relative to the problem of coagulation. Must we, indeed, believe that we may discover by the anatomical method the conditions under which the blood coagulates in the vessels of a living man? No; the immense majority of pathological processes can only be explained by the method used by physiology, that is to say, by the observation of the whole of the phenomena in chronological order, and by experimentation.

You will say to me, that, to observe the succession of morbid phenomena is the affair of him who sees the living patient, and not of him who only finds himself in face of it some time after the disease has terminated; in other words, that it is the office of the clinician, and not of the anatomo-pathologist. This seems very just, but it is only so in appearance, for what the clinician observes at the bed of the patient is not the process of the disease, but only a series of signs called *clinical symptoms*, from which we can, as regards the manner in which these things really happen, conclude nothing more than the anatomical signs disclosed by the examination of the cadaver. When we find a part of the body red, swollen, painful; in short, in a state which at all times has been regarded as pathognomonic of inflammation, this makes us acquainted with nothing of the essential process of inflammation, that is to say, of the nature of the circulatory trouble, no more than the macroscopic, microscopic, and chemical examination of the exudation that we gather from the cadaver.

Here is a man quickly seized with very intense dyspnœa, his pulse is small, his face cyanosed, his respiration embarrassed, noisy, and hurried; the ear perceives on auscultation very extended rales in both lungs, and the cough expels a quantity of frothy fluid. We assert that the pulmonary alveoli are filled with an aqueous liquid as surely as if we saw it in the lungs directly after death; but neither this nor that clears up to us the morbid process, the manner in which this inundation of the pulmonary vesicles is accomplished. The human organism is too complicated, and the problems of pathology are not simple enough for the observation of symptoms alone, to be able to fully explain pathological facts; indeed, I have already said that the establishment of anatomical signs is also quite insufficient. Undoubtedly both are absolutely indispensable, since without them we could not even suspect the existence of disease; they complete each other in the happiest way, and their combination is so useful to our speculations that we can no longer understand the mutual disdain formerly common between clinicians and anatomo-pathologists. But though a patient may be observed so exactly during his life, and so carefully examined after his death, all that we can say, in the greatest number of cases, of the essential process of the disease, is how it is *perhaps, probably* produced; in the most favorable cases we can eliminate certain hypotheses. As regards absolute certainty, it can be obtained only by a much more delicate analysis of the different possible circumstances; it may be by estimating them comparatively in the divers combinations shown by diseases, or we may have recourse to the method that allows of their examination singly and of varying them at will, that is to say, to experimentation.

Without experiments, there can be no scientific pathology, no pathological anatomy, unless in the latter we wish to limit ourselves exclusively to the study of those processes previously indicated, which the anatomical method can solve by itself. But whoever is likewise interested in other morbid processes and desires to understand them, will not easily relinquish experimentation. That is the ground on which the works of the anatomo-pathologist and of the clinician meet, without the possibility of our being able to define clearly the domain of one from that of the other. Should we reduce the former to elaborate only that part of pathogeny whose aim is to explain the anatomical signs? This curtailment of its field of work would be very cruel to it if it were possible. In vain the anatomo-pathologist has endeavored to limit himself to problems of human pathology the most purely anatomical in appearance; he would always be carried away by the infinite complication of the human organism and its economy towards questions perfectly foreign to anatomy. Thus hypertrophy of one or other half of the heart, following certain cardiac or pulmonary lesions, is undoubtedly a process of growth: but it is still more certainly

an anatomical problem; but, however, it is absolutely impossible to comprehend how these hypertrophies are produced and formed, without knowing the influence on these lesions of the function of the heart and the manner in which this influence exerts itself. Thus, again, can the anatomo-pathologist, studying inflammation, only busy himself with the swelling and redne s alone, neglecting the heat and the functional lesion? And in nephro pathology, should he restrict himself to the cardiac complications and the œdema, without investigating the uræmia because it has no anatomical criterion? I do not deny, I must say, that certain questions of pathology relate more naturally to the clinique than to anatomy: for instance, no anatomo-pathologist would pretend to be able to determine the mode of production of cardiac and pulmonary sounds with more success than the clinician, and the latter should willingly abandon to the other the study of the pathogeny of incrustations. But there is no difference of principle. The clinician and the anatomo-pathologist both have as a task the scientific exploration, in every sense, of the morbid process, and, as an aim, the knowledge of the laws of morbid life.

He who thus understands pathological anatomy, and sees in it more than a purely morphological science, has no occasion to ask whether it is possible to *completely separate patho'ogical anatomy from pathological physiology*, and whether the instructing medical body should endeavor to do so. It is easy to comprehend why this has been done in the case of normal anatomy and physiology. The separation everywhere accomplished between them in the last ten years has greatly favored their progress, but, in my opinion, nothing similar must be hoped for in the case of the two corresponding pathological sciences. For normal anatomy and physiology, are two quite distinct sciences, one independent of the other, each properly possessing different methods. The anatomo-pathologist, by not cultivating pathological physiology, will henceforth relinquish the opportunity of understanding the great part of the subject of his studies, just like the clinician who will content himself with finding out the symptoms of the disease. To appreciate, on the other hand, how little advantageous would be the complete isolation of pathological physiology, it suffices to cast a glance on the chairs and the institutions of experimental pathology of most of the universities of a neighboring country, the German universities never, as far as I am aware, having fallen into a like error. Nearly all the good work that has been done in that country is relative to physiology, foreign to pathology. This is an easy thing to understand. Experimental pathology that relies only on itself, that seeks to have no relation either with the bed of the patient or with the autopsy room, fails in that which never fails in physiology; it cannot propose questions to itself. It is only by the observation of the signs of disease that are raised up for the consideration of the pathologist, the etiological and pathogenic problems, and without the constant occasion of observing very exactly the morbid signs, whether clinical or anatomical, the most intelligent and penetrating man will soon have exhausted the series of pathological problems, unless he enters upon a field where the interest of the physician does not follow him. To discover the laws of morbid life, in other words, to cause general pathology to progress, there must be a clinician or an anatomo-pathologist. To ask to which of the two is it preferable to confide didactic teaching, is to put an idle question, which, put thus in a general manner, does not deserve a reply; but we may maintain that it would be best to partake of the two. In case that, from a practical point of view, this division may be unacceptable, it would then be allowable to recommend, as a general rule, in presence of the duties so great and so justified that are laid on the time and on the work of the teachings of the clinician, the hospital, and also the public, to confide by preference this instruction to the anatomo-pathologist. But as, moreover, that solution militates against an extrinsic circumstance, though one not devoid of importance, I must speak of the experimental character of the course on general pathology. The idea of preparing and instituting experiments in a hospital affrights every one, and justly, while all the preliminary conditions for this indispensable thing are ready and already realized in anatomo-pathological establishments, which, precisely by cultivating experimental and general pathology, have become the *pathological institutes*.

And now, will you believe that it was unbearable presumption, when, on commencing, I claimed for pathological anatomy the privilege of throwing a bridge over the abyss that separates physiology from the clinique, and making comprehensible to the young physician, after the first half of his studies, what awaits him at the bed of the patient? Certainly, if the professor of pathological anatomy had no other role than to carefully practice his autopsies, to prepare nicely his specimens, to examine them well under the microscope, and finally to describe exactly and faithfully the result of his examination, he could scarcely, as useful as his labors may be, pretend to any considerable influence on the mind, and the mode of view of the students, and to a certainty he could never obtain this influence. It is only on condition of being a pathologist, on condition of maintaining pathological anatomy in intimate and permanent contact with general pathology, that he elevates it to the height of a true science, the servant of the clinique, in fact, its worthy and legitimate sister. Undoubtedly in the ratio that the aim increases, the distance from us of the end also extends. So, therefore, those who seek from the sciences the peculiar satisfaction that its masterpieces, all of whose parts are equally completed and achieved, procure, may place at a distance those who are dissatisfied with pathological anatomy thus defined. But under this aspect, it would have the greatest charm for those who, far from being frightened by the number of problems still unresolved, can unceasingly, with fresh encouragement, put forth their natural powers.

[Continued from SUPPLEMENT, No. 202, page 3193.]

THE BEGINNINGS AND THE DEVELOPMENT OF LIFE.

By PROF. EDMOND PERRIER.

LET us now return to our sponge embryo. After swimming about for some time it sinks to the bottom and proceeds to fix itself to some rough projecting part of the soil. Then the hemisphere composed of amœboid cells is observed to encroach more and more upon the flagellate hemisphere, and the latter seems to turn itself inside out and enter into the interior of the first, the embryo being thus gradually transformed into a sphere composed of two layers—an internal one derived from the monad-like cells, and an external one derived from the amœboid cells. The latter soon become so fused together that they are distinguishable only through their neuclei; but the mass that they form still preserves for a long time the faculty of lengthening out

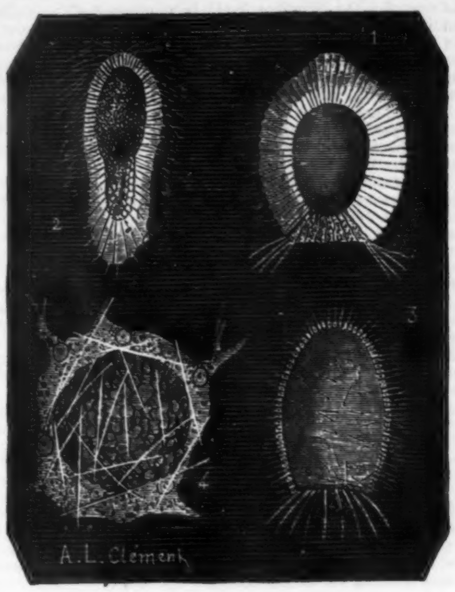


FIG. 1.—LARVÆ OF SPONGES.

1. Larva of *Verongia rosea* (fibrous sponge).—2. Larva of *Halisarca lobularis* (gelatinous sponge).—3. Larva of *Isodyctia rosea* (silicious sponge).—4. Young calcareous sponge whose external surface is still possessed of Amœboid movements; the osculum not yet formed (*Sycandra raphanus*).

FIG. 2.—CALCAREOUS SPONGES.

Arborescent Colony of *Ascandra pinus*, Haeckel

FIG. 3.—SKELETON OF TWO SILICIOUS SPONGES, NATURAL SIZE.

1. *Alcyoncellum speciosum*, Quoy & Gaimard. 2. *Euplectella aspergillum*, Owen.

into pseudopodia, which serve to fix the sponge (Fig. 1, No. 4). At this period the sponge exhibits no orifice. Soon the spicules make their appearance, the osculum forms, and then the pores. The being which results from the metamorphoses of the embryo is a simple sponge having more or less analogy with an *Olynthus*. Embryogeny too, then, leads us to regard the latter form as the true individual among the sponges. Subsequently, in those sponges provided with vibratile cell chambers, vacuoles form in the mass, and the amœboid cells which line them become transformed into monadoid cells. What we have just said applies especially to the calcareous sponges, whose embryogeny exhibits in addition some points that are still doubtful or obscure. In the silicious and gelatinous sponges we find larval forms which are slightly different. We have caused some of these to be figured from the interesting memoir of M. Charles Barrois (Fig. 1, Nos. 1, 2, and 3).

In these groups, simple sponges are rarer than in that of the calcareous ones; but as an offset to this they attain a much larger size, and an elegance of form that surprises the observer. Among the most remarkable of these sponges we may place in the first rank that magnificent *Alcyonellum speciosum* collected for the first time by Quoy and Gaimard during the voyage of the Astrolabe, and the beautiful *Euplectella aspergillum* from the Phillipine Islands (Fig. 3, No. 2).

These large sponges have no oscula. Their skeleton is formed of a silicious network, transparent as the clearest rock crystal, and as regular as the most charming lace. The main portion is composed of six-branched spicules, but these are bound together by silicious fibers which give great solidity to the sponge tissue. It is in these sponges that we find skeletons of the most regular and complicated forms. *Alcyonellum speciosum* has always been rare, but the naturalists of the Challenger gathered some beautiful specimens of it. *Euplectella*, on the contrary, have become quite common. Notwithstanding their beauty, and the wonder that they always cause when they are seen for the first time, they may be bought for a couple of dollars at any natural history store.

We have determined the simple form of the sponges, and what in the sponge group must be called an *individual*.

The sponge individual may be regarded as a sort of urn, whose walls pierced with holes give passage continuously to the water which proceeds from the opening (osculum) of the urn. We have seen how this individual might be connected with unicellular organisms, and even with the moners through a series of successive forms. The following may be given as a *résumé* of this evolution: The unicellular beings are reproduced first by division into two like parts; then the reproduction is effected in the interior of a cyst, and consists in a division of the protoplasmic mass into a great number of parts whose form, which is definite, is different from that of the parent; the flagellate Zoospore, the Monad, thus succeeds the Amœba and alternates with it. The Zoospore form gradually becomes the more important of the two, and thus arises the group of flagellate Infusoria. Amœbæ and flagellate Infusoria acquire the faculty of dwelling in societies composed of individuals all like one another.

In these societies each individual is at first entirely independent of his neighbors, and preserves an almost complete personality; but gradually this personality is obliterated, absorbed in some way by that of the society; the primitive individual falls from his rank, and is no longer anything more than a part of a new individuality, one of the wheels of a machine; and finally the two Amœboid and Monad forms associate themselves to produce, with some modifications of detail, the sponge individual, in which both may be more or less completely fused together.

Well then, this sponge individual once formed, lends itself, in its turn, to exactly the same combinations as the unicellular individuals—the elements of which it is composed. A certain number of individuals bud, at first, one upon another, preserving at the same time their entire independence, as shown among thousands of other forms by *Sycinula ampulla* (Fig. 5, No. 3, of the preceding article), which seems to be only a colony of *Olynthus* united by their bases. In the arborescent colonies of *Ascandra pinus* (Fig. 2), the different component individuals are as yet quite distinct, but their respective limits are already often difficult of determination. Their central cavities all communicate directly with each other so as to establish between all the component individuals very close relations as regards the subject of nutrition; some of them are also seen to live as parasites, so to speak, at the expense of the colony, their osculum disappearing and their neighbors being charged with the duty of eliminating the water which penetrates through their walls. This is a beginning of *polymorphism*. It even happens in certain colonies that several individuals which are at first distinct from each other, unite together by their upper extremity so as to have but one osculum in common. A number of species exhibit this phenomenon; and even colonies of the same species, born of different embryos and growing in the vicinity of each other, are seen to fuse together just as the individuals of a same colony may do. This is the phenomenon which Haeckel has called *concrescence*. Finally, in the majority of cases, the individuals composing a same colony fuse together to that degree that it is impossible to trace any line of demarkation between them; and the number of the component individuals can then only be determined by that of the oscula; and as certain individuals may be, as we have seen, deprived of this orifice, this enumeration itself is far from accurate.

Usually, however, the different individuals of a colony have narrow spaces between them, and through which the water can circulate in order to enter the sponge by means of the pores. From this results a system of canals very distinct from that due to the fusion of the digestive cavities, and which are observed in a great number of colonies. The common toilet sponge is one of the compound species in which the fusion of the individuals composing the colonies is carried to the highest degree. Yet this fusion may become such that the character of the colony disappears in its turn. The colony becomes an *individual* again, or, as Haeckel says, a *person*.

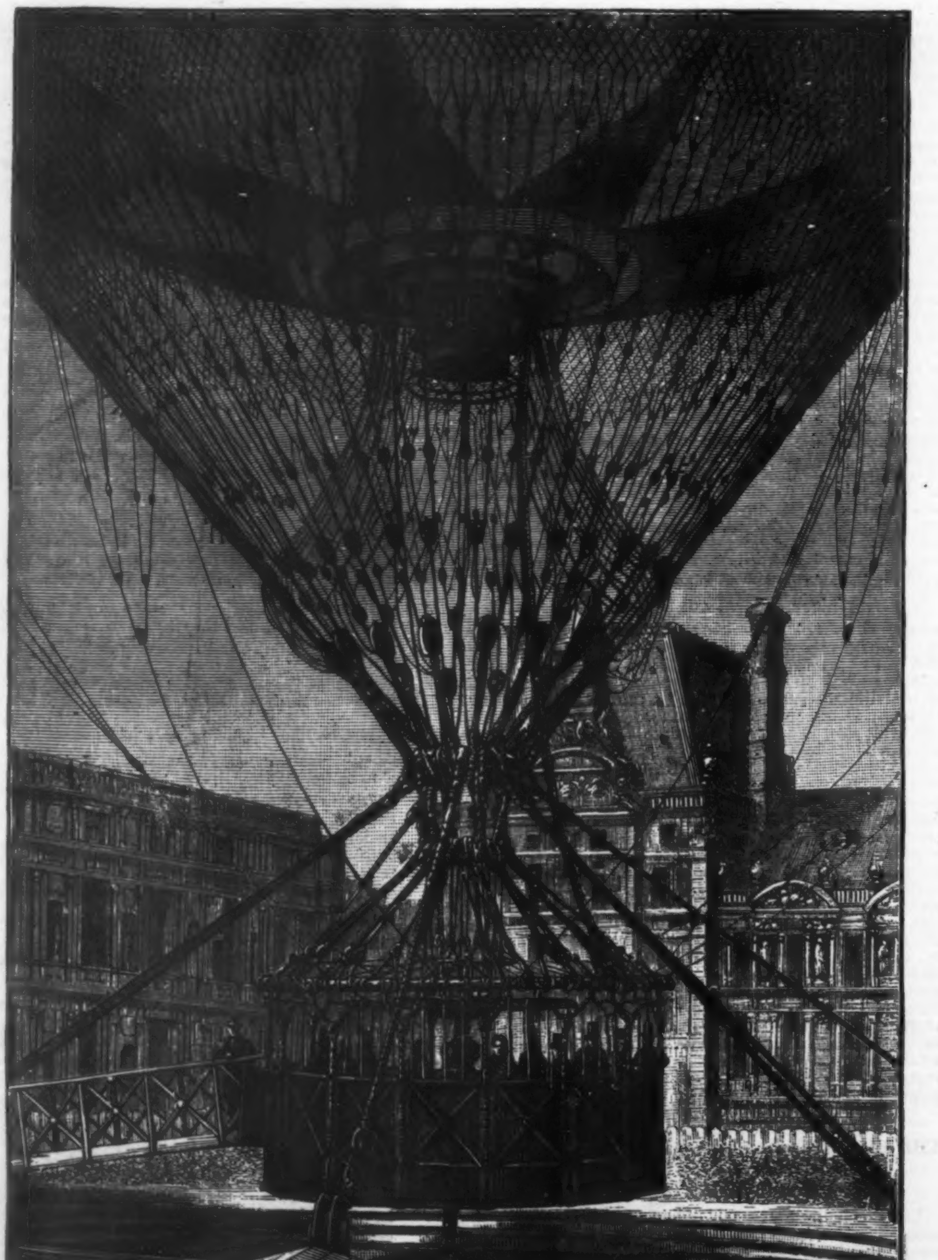
Certain calcareous sponges composing the family of *Syncones* of Haeckel resemble *Olynthi*, but their walls, instead of being thin and perforated with holes, are thick and traversed by canals radiating quite regularly around a central cavity. At first sight they might be taken for thick-walled species of *Olynthus*. Haeckel, however, thinks that they should be considered as colonies; and according to him, each of the radiating canals is the digestive cavity of a particular individual sprung, by budding, from the external wall of the primitive *Olynthus*—that one in whose cavity end all the radiating canals. The *Syncones*, then, would be colonies whose component individuals have fused in such a way as to reconstitute another individual of higher order—an individual simple in appearance, but in reality composed of *Olynthus*, as *Olynthus* itself is composed of unicellular individuals. This would be the last term of the evolution of sponges. This manner of regarding the *Syncones* is somewhat theoretical; but what remains still doubtful in sponges takes place with remarkable clearness in a neighboring group, that of the Hydra polyps, as we shall soon show. There, Hydras, which as organisms are comparable with *Olynthi*, really do associate together according to definite rules to form new organisms, true individuals compound to the second degree.

In general, the individual of the colony among the compound sponges is quite vague, and its form remains so wavering that different genera have actually been created to receive individuals belonging to the same species. In fact it is very troublesome to determine what is to be understood by the term *species* among the sponges. The external form would rarely serve as a guide, and the form and mode of grouping of the spicules are exceedingly variable. Haeckel, who has studied the calcareous sponges, and Oscar Schmidt, who has studied the horny and silicious ones, both arrive at the conclusion that there are no species among the sponges; and such a phenomenon should not surprise us after what we have seen in the Rhizopods. Sexual generation is yet scarcely indicated in the sponges; in all cases it appears to result from the reciprocal action of elements arising from the same individual. A sexual generation, then, has a predominant importance in this group. In the group of Hydra polyps, which we shall speak of in our next article, sexual generation, on the contrary, assumes its definite characters; species at the same time clearly asserts itself, and the concordance of these two phenomena makes us comprehend how the apparent fixidity of the present species, far from being an argument against the theory of descent, bears witness, on the contrary, in its favor.

(To be continued.)

THE END OF THE GREAT CAPTIVE BALLOON.

WE have described the captive balloon of the Court of the Tuileries in too much detail not to record in this place the last chapter of its long and glorious career. After working so admirably last year, and after accomplishing more than a thousand ascensions, and carrying more than 35,000 passengers during the progress of the Exhibition of 1878, the great air ship was again inflated during the first days of June, 1879, and its car was opened to the public on the 15th of the same month. Dating from this time, the season was so rainy, and the air so frequently disturbed, that the ascensions were constantly interfered with by the weather. Yet there was no want of ascensionists; far from it, indeed, for they presented themselves in great numbers as soon as the anchorages of the balloon were removed, thus proving that the public had not yet become tired of contemplating aerial panoramas. Saturday, the 16th of August, was destined to be the last day of the captive balloon. In the afternoon, the wind arose with extreme violence at Paris, and, at four o'clock, large black clouds poured forth torrents of rain into all the streets, and that too in the midst of a true cyclone. The great captive stood the great shock of tempest, but unfortunately it was not entirely filled with gas; the tissues, instead of presenting a rounded and convex surface to the wind, became full of concavities, and gave an enormous purchase to the hurricane. The stuff being lifted with great force at the lower part of the balloon, carried along with it the 880 pound valve, and this, in falling again, subjected the material to a severe strain. At 25 minutes before 5 o'clock, the tissue, notwithstanding its strength, gave way, and the rent enlarged until it extended as far as the upper pole of the immense sphere. The twenty-five thousand cubic meters of hydrogen inclosed therein were in an instant disseminated through the atmosphere, and the collapsed balloon fell to the ground. It is certain that the accident would not have happened had the captive been entirely filled with gas. Next year M. Henry Giffard will perhaps undertake the construction of another captive balloon, and if he does, he will add to his gas apparatus a gasometer, which will allow of the sphere being filled almost instantaneously whenever the hydrogen becomes condensed by a sudden lowering of the temperature. The balloon will thus be protected from sudden hurricanes. To-day we publish, as a supplement to our preceding descriptions, an engraving which faithfully depicts the car of the great captive. To the left of the picture is seen the little movable gang-plank through which the passengers walked to enter the gallery of the circular car. The latter usually contained forty to fifty persons at every ascension. The car is shown at rest, and on the sides are seen the strong cables which fastened



THE CAR OF THE GREAT CAPTIVE BALLOON. Paris, 1878–1879.

it to terra firma. It is suspended above the well, at the bottom of which passed the cable through the large pulley; it is connected with the netting by the ingenious system of cordages and pulleys which caused the admiration of all visitors. Our engraving shows the lower part of the sphere, and the terminal automatic valve, of which we have before spoken. The picture that we publish is perfectly exact, and we are persuaded that our readers will regard it with interest, and as a souvenir of one of the boldest and most beautiful mechanical constructions of modern times. They will remember that this work, which was due to private enterprise entirely, was the greatest success of the Universal Exhibition of 1878. The eminent engineer, who constructed it at his own expense, risk, and peril, conceived it and undertook it with a disinterestedness that is rare in our time, and with no object in view other than that of serving science and doing honor to the city of Paris. When the honorary awards were distributed, he alone (would it be believed?) was forgotten.—*La Nature.*

THE SOLAR TEMPERATURES.

By J. JANSEN.

THE author considers that the nucleus of the sun is much hotter than the photosphere or any of the exterior strata. The expression "solar temperature," is deficient in precision. The calorific and thermo-electric methods generally employed seem capable of a rational use for determining the thermic power of the solar radiation which arrives at the earth's surface, but they cannot give exact notions as to the real temperatures of the sun, not even for its mean temperature, an expression which as applied to the sun seems almost without meaning.

WAYS OF REMEMBERING.

By J. MORTIMER GRANVILLE, M.D.

THE fact that there is a practical difference between *knowing* a thing and being able to *remember* it is sure to be brought home to the student in any branch of science, very early in his career. What precisely is the nature of this difference, and how is it to be adjusted? Before we try to find answers to these homely but earnest questions, let us expose and put out of the way a source of misconception which often occasions trouble and disappointment to minds admirably fitted for intellectual work, but inexperienced in the exercise of their powers and faculties. A man of acute and clear perception, endowed with a quick understanding, will comprehend a subject, take it in with a rapid mental glance, and seem to have made it his own. He "learns easily," but, alas! he forgets with even greater facility. The truth is that he has never *learnt* in any mnemonic sense. What he has done is to *apprehend;* and although the brain is undoubtedly capable of a process analogous to instantaneous photographing, it rarely performs this function at the behest of the will, unless it has been specially trained to do so; or when it does thus instantly receive an impression, the record is not permanent. The faculty of instantaneous mental photography is more commonly the agent of the sub-consciousness than of the supreme consciousness, and it takes in the impressions we would gladly have effaced, while those it is desired to retain are obliterated almost as soon as they are registered. Apprehension is a function of the intellect, which may be, and in the case of what are called "clever" persons often is, developed to a high degree of efficiency without any corresponding exercise of the recording faculty. Just as a man may work out a problem or perform an arithmetical calculation with perfect command of the data and processes involved, but in no way burden his mind with the details, or even the result of his work, if these do not personally concern him, he may concentrate attention and bring his reasoning faculties to bear on a subject of study and master its details, so as to obtain a clear comprehension of the whole while he is not registering any impression to form the basis of memory. Indeed, it is a notable circumstance that in a large class of minds the faculty of apprehension is developed, so to say, at the cost of that of mental registration or memory, the whole force of the intellect being, as it were, expended in understanding, while the storing of impressions is left to chance, which generally means that it is wholly neglected. It is therefore important to bear in mind that a quick understanding does not either involve or imply an aptitude for study. It is simply an effective power of perception, and is not uncommonly associated with a proneness to forget, which is in truth the effect of an absence or inefficiency of the faculty of mental recording. The distinctness and almost antagonism of these two functions of the mind, understanding and memory, is curiously apparent in the fact that idiots have often extraordinary powers of retention and recollection, while the most intelligent hearers and readers often find to their cost that they are the most forgetful. The student should not allow the consciousness he may have of a quick understanding to encourage him in the neglect to cultivate his memory, or be misled by a "good memory" to assume that he is endowed with high intellectual ability.

It is, undoubtedly, possible that the mind may be duly charged with a record of any subject or any information, and be unable to remember it at will. This circumstance arises from the fact that memory concerns the *method* of recording rather than the record itself. A piece of knowledge—if I may use the term—is often put away safely in the archives of memory, but no care has been taken to mark the place or leave a clew for its recovery when wanted. It may turn up at any moment, but cannot be produced by the will, for the simple reason that *will* has not been concerned in putting it away, or is not orderly in its action and trained to the task of recollection. The difference between knowing a thing and being able to remember it, is the difference between having a piece of property and knowing where to find it. The way to adjust this difference is to make the act of recording impressions a part of the process of receiving and shaping them. This is what some persons try to do by a recourse to what are known as "technical memories." Those who attach value to these devices must bear with me when I contend that they are not in harmony with the laws of psychology, and are therefore unscientific. It would be absurd to assert that they are useless, because every one knows that "bodfi" has helped many a bewildered student to remember that the descending horn of the cerebral ventricle has a course *b*ackwards, *o*utwards, *d*ownwards, *f*orwards, and *i*nwards; but clumsy and needless tools have often been employed in good work, and nevertheless wisely thrown aside when it was found that the work could be done much better without them. The natural and only true basis of memory is a well-formed impression. It is not essential that the impression should be fully understood at the time it is made, or the subject-matter wholly mastered by the understanding, but if the record is to be found by thought at pleasure, it must be registered by thought, and in such a way as to be easily recoverable. If the will is to control the act of recollection, it must be directly concerned in that of recording, and it will greatly facilitate the cultivation of a "serviceable memory" if the processes of apprehending and recording are studied together and intelligently combined or correlated.

The organ of the mind it connected by several lines of communication with the external; and impressions—or more accurately the agents of impression—travel more freely along some than others. One man will be more effectively impressed by what he hears than by what he sees, and so on. Probably the deepest, clearest, and most permanent impressions are those made when the subject matter is communicated to the brain by several senses at the same instant, or at least during the same observation. For example, the impression received from an object that can be seen, heard, felt, and perhaps brought under cognizance by the olfactory sense simultaneously, will be deeper and clearer than that of another object which can only be recognized by a single perceptive faculty. Nevertheless, most persons have a special aptitude for receiving impressions through some particular avenue of the senses, and it is important for the student to ascertain which is the most open and sensitive of the lines of communication in his individual case. A simple experiment, which may be described as follows, will, if carefully performed, supply the information desired. Let some other person write on a slip of paper, which we will call No. 1, six or eight familiar words consisting of a single syllable, in such order that they shall not have any connections of meaning or sense.* Let him next write the same words in a different order on another paper (No. 2), again av..ding any arrangement which might connect the words in thought by sound, sense, or meaning. The person to be experimented upon must neither have seen nor heard the contents of the two papers, or know the precise number of the words written. Now place the paper No. 1 before him, and let him read it once only, and silently, so that no element of sound may be imported into the experiment. Then let the paper be removed, and let him at once write down from memory the words just read in their order. This should be done as quickly as possible, because the purpose of the experiment is not to test the permanence of the impression, but the readiness and clearness with which it is formed. As soon as he has written all he can recollect, remove the paper, without waiting for any correction or addition, and mark it No. 1 for reference hereafter. Next let the person who wrote the words on paper No. 2 read them once, clearly, at an ordinary rate, neither too fast nor too slow, and without any particular emphasis, and let the student after he has concluded immediately write down what he can remember. The result must be quickly removed with the same precaution as before, to avoid after-thought, and the paper marked No. 2. The process is then to be repeated in an inverse order, the words chosen being different, and the arrangement as heterogeneous as in the first stage of the experiment, but the oral reading being given first, and the paper which is read at sight subsequently. The papers containing the results are to be marked with the numbers corresponding to the test papers. The two sets of papers are now to be carefully compared, and a judgment found on the basis of general accuracy as to the words and their order. If no great difference is apparent in the results obtained, the experiment may be repeated with any variation, such as the substitution of figures for words, but the conditions must be carefully adjusted, so that memory is not helped, or the burden of the trial will be thrown on the recollection instead of on the faculty of receiving impressions. It will not generally be difficult to form a clear notion of difference between the aptitude displayed for receiving by ear and by eye respectively, and the readiest faculty will be the one on which it is safest to rely so far as *taking in* knowledge is concerned. The man who appreciates most readily by ear should not, as a rule, take notes at lecture, whatever he may do afterwards; while the student who is not so expert in receiving notions from the ear as by the eye may do wisely to take down a lecture in shorthand, or even write a full note, by way of impressing it on his mind. The latter will also probably find that he derives more advantage, generally, from reading books than from oral instruction.

It is, however, necessary to know more than this experiment has, so far, communicated. The faculty of reception is one thing, that of retention another. In order to explore the latter, it will be desirable to repeat the experiment already described with new word materials, and to allow an interval of, say, half an hour to elapse between the reading by sight and writing from memory, in the one case, and the same time between the dictation and writing in the other. Great care must be taken to render the intervals as nearly as possible equally distractive as regards the way the mind is employed, and by reversing the order of the sight and sound tests, as previously indicated, to correct any error likely to creep in from the fact that when the same words are brought a second time under cognizance they are, of course, recent or familiar. This further experiment will throw new light on the comparative efficiency of the two faculties as recording agents, but to obtain the full information required, the four sets of test and result papers must now be examined from another standpoint. The *nature* of the mistakes made is not less suggestive than the relative amount of accuracy. As a rule, persons who habitually remember by ear—that is, by calling to mind a *mental record* of sound—will, when writing from memory, make mistakes suggested by similarity of sounds; the words written, if not the right ones, will be of somewhat like sound; while specially soft-sounding words or syllables are likely to be omitted. On the other hand, those who remember by *pictures of thought or mental characters* are notably apt to substitute words that bear a general resemblance to each other in their own calligraphy, and to drop words or parts of words, as though writing hastily from an ideal copy. A very little reflection will make it apparent that by bestowing a few hours to the scrutiny I have suggested any man may obtain a considerable and useful insight into his individual way of remembering, and on the basis of the knowledge thus acquired he will be able to determine which of his powers it is best to cultivate. This initial point being settled, we may proceed to indicate briefly a few of the most practical methods of developing the faculty it is proposed to train to the highest attainable excellence, which, of course, will vary with the individual energy, intellectual force, and perseverance.

When the student knows that he takes in most accurately and remembers with the greatest readiness, by sound, he should arrange his method of study so as to work this faculty directly. For example, he will be especially diligent in his attendance on lectures, and to avoid as much as possible being distracted by sounds other than those which convey instruction. He will read aloud when studying in private, and impress the matters he desires to remember upon his mind by audible repetition, as a child learns his lesson by repeating it over to himself until he knows it. He will do more, bearing in mind the need of clews or threads of association by which to recover the matters put away in the brain; he will take care to create for himself in the act of learning a sufficient number of *sound*-links which shall connect the facts he desires to remember with others. The various technical formulæ constructed by teachers and recommended to the student, fail first because they are not the creation of the mind which employs them; second, because they are non-natural and arbitrary; and third, because the essential difference between a faculty of remembering by *sound* and by *sight* not being recognized, the formulæ adopted are often uncongenial. Each student ought to make his own connecting links for ideas, and they should be natural, scientific, and appropriate to his special faculty. The man who remembers by sound will find it easier and better to remember a chemical decomposition, the characteristics of a bone, or the relations of an artery by some formula which connects them by sound than by trying to *picture* the subject, while the reverse will be the case with the man who remembers by sight. The latter must fancy he sees the object or recall to mind some written or printed description of it before he can remember the details. The man with a memory for sounds will do wisely to employ that faculty constantly. The voice of his teacher will help him, the sounds of letters, even a sort of musical notation, which he will construct for himself intuitively, will contribute to the efficiency of the service sound renders him. The points for him to bear in mind are that in learning, sound-links or connections must be formed, and in *remembering*, the posture of mind should be one of mental listening, because it is through a thought-sound the matter will be brought back to the consciousness. When, on the other hand, sight is the readiest mode for the reception of impressions, and is also the medium of memory, the aim must be to *picture* every matter it is desired to remember either in the shape of an ideal image of the object, or a written or printed description of the subject.

Professors of memory, taking advantage of the large number of persons who remember by mental *imagery*, have developed the system of teaching by pictures to great perfection. With the aid of a few mental images of squares, or figures more or less simple, they will enable a very dull scholar to "recollect" the most complicated figures and dates, or a seemingly bewildering array of facts. The formula of memory is in all these cases associative, and the lines or spaces employed to fix the several objects of thought stand for the connecting links. Every way of remembering is, as I have said, a process of link-making, and when a simple formula can be made to serve a variety of purposes—acting as the frame for a multitude of pictures—the task is simplified, and the result, for a time at least, proportionately certain. A picture-memory requires that the threads or connecting links by which any subject is to be recovered shall be pictorial; and to make the process natural these links should be as far as possible the actual surroundings of the object to be remembered. The student who has a memory of this class should learn his anatomy from personal dissection, and it will help him greatly if he can draw so that the subjects of thought may be impressed on the mind by sketching. Such a man will do well to employ the pencil more than the pen, and even in the study of a subject like chemistry to employ diagrams largely. There is scarcely any topic which may not be illustrated by figuring of some kind, and the hieroglyphics employed ought to be of the student's own personal devising, except when a teacher has first presented the facts pictorially, in which case it is better to accept and adopt the original imagery, on account of the strength of first impressions, and the confusion that might be caused by changing the symbol. A common error into which beginners are apt to fall is to try to combine, and therefore confuse, the two methods of remembering—by *sight* and by *sound*. They should be kept carefully apart, and only one adopted—whichever is found to be the most natural and susceptible of culture, in conformity with the law of development, which makes growth and efficiency the fruits of exercise.

A close scrutiny of the results obtained by the experiments above suggested will show that there is a class of cases in which knowledge is received by one line of communication and remembered by another. The *number* of errors may be greater when writing from sight or sound respectively, while the *nature* of the mistakes made points to the other medium as the agency concerned in remembering. When this happens, it will be needful to cultivate the two faculties side by side, and this may seem to create a difficulty. In practice, however, it is easy to make the requisite discrimination, and after the learner has matured his method of study he will find that the doubling of the process really economizes time by improving the quality of the work done. The feat to be accomplished is simple enough, and bears a close analogy to the procedure of an arithmetician, who "proves" his sum; having added, he subtracts, or the converse. So the learner by sight who remembers by sound must take in his subject by pictures or characters, and practice reproducing a verbal account of them. If he *hears* most readily and remembers by *sight*, he will do well to listen, and, as I have said, read aloud when studying, then come away, or close his book, and proceed to picture what he has been thinking about, and draw or write a description of the imagery, to impress it permanently. This is what hundreds of persons do unconsciously, and if the process be necessary in any case it will be found to be natural and easy.

There is nothing novel in these suggestions beyond the recommendation of a formal experiment to ascertain which of the several sense communications is the most available for practical purposes. All that I have indicated as desirable to do is done intuitively by expert scholars; but as intelligent and self-controlled beings, we ought to know the nature and purpose of every intellectual process, and to the young man entering on a career of special study it will be helpful to receive a few hints as to the best mode of procedure. It does not concern the student standing on the threshold of his field of inquiry to know in what the physical bases of memory consist—if, indeed, any one is in a position to give him precise information on the subject—but it is of use to him to be told *how* he remembers, and how to choose the readiest and most effective instrument for the task he has to accomplish. It is a higher and a better thing to possess the power, and know where to acquire information when it is wanted, than to carry about knowledge as a pack-horse bears his burden. At the same time there is so much which it is

* If the number of words suggested should prove too great in any case a smaller one may be employed, but it is necessary that the words should be arranged so as to avoid any connection, or the result will be misleading; the ideas will be less in number than the words, whereas it is essential that each word should represent an independent and distinct idea. Figures would do as well as words but that they too readily combine to represent compound ideas, and for our immediate purpose we must use simple ones.

indispensable the student should learn to hold in memory, that I venture to offer these few hints as to "ways of remembering."—*London Lancet.*

THE FRENCH ASSOCIATION.

The French Association for the Advancement of Science has held its annual meeting at Montpellier, from Aug. 21 to Sept. 4, under the presidency of M. Bardoux. Public lectures have been delivered on the Rhone irrigation canal and on the electric light.

SOUND VIBRATIONS AND THE TELEPHONE.

By Prof. A. E. Dolbear, College Hill, Mass.

Since the invention of the speaking telephone there have been, both in Europe and in America, a considerable number of persons who have been dissatisfied with the ordinary explanation of its action as due to the correlation of ordinary sound vibrations of an inductive substance and magnetism, these two resulting in electricity, and such persons have sought to explain the phenomenon by supposing some molecular action different in kind from those with which we are familiar. I have not been able to find any expression of opinion as to how this so-called molecular action differed from ordinary sound vibrations, but have seen a good deal that has led me to infer that the structure of a compound sound vibration is not understood by those who declare for the molecular action; and again, it does not appear to have occurred to any of them that a molecular action, such as they argue for, implies a form of energy hitherto unknown, and is therefore without a name.

Among the forms of energy the laws of which are known, we name: 1st. Mechanical motion, which consists in the displacement of the center of gravity of a mass of matter. 2d. Heat, which consists in the internal vibration of a molecule without displacing its center of gravity. 3d. Electricity, which consists in the internal motion of a molecule, the form of the motion being probably one of rotation. 4th. Magnetism, the result of rotating molecules, which stands to electricity as gravitation does to a raised weight. 5th. Chemism, which consists in the selective agency of molecules, by which exchange of energy is determined among them; and lastly, Gravitation. We have no knowledge of any others, and if by the term *molecular action* is meant some form of energy different from the above forms, then plainly we have a new form of energy which should have a new name.

But, before a new force is summoned, it will be well to see if the familiar forms are not competent to do everything that has yet been observed in telephones. Consider, first, the magneto-telephone as a transmitter. Sound vibrations made in the air impinge upon an inductive plate of iron, which makes it to vibrate backward and forward in the field of a magnet, and currents of electricity result if there be a proper circuit. Now, it has been inferred that the inductive plate does not vibrate—at any rate, not in the ordinary way, since, when the plate is very large, as it has sometimes been made, it still continues to act inductively as *if it did vibrate*, but owing to the size or the mass of it, it has been thought that it *could not do so* to an extent sufficient to produce the observed effects, that is, that the plate does not perform anything like a pendulous vibration. In order to understand what must take place, it will be necessary to call to mind the structure of a sound wave in air and other media. Suppose, then, a simple sound wave in air with a wave length of one foot. If such a wave when formed could be made visible and kept stationary, it would be seen to consist of a dense part and a rarefied part, and if there were one hundred molecules in the length of it these would appear a little closer together by about the one-sixtieth or the one-eightieth of their ordinary distance, which represents the one-half of the actual displacement of one molecule by the movement called a sound wave. The displacement of a molecule of air for an ordinary sound wave is something like the one-millionth of an inch. Its direction of motion is to and fro, in the direction the wave travels, and if one could observe the motion of a single molecule it would be seen to vibrate about 1,100 times per second, and all that would be seen would be simply this to and fro movement, as if it was the bob to a very short pendulum. It is purely a mechanical motion of a molecule, but not what is implied by the term molecular motion or action, as manifested in what is called heat, for there is a change of position of the whole molecule with reference to other bodies, whereas in heat the molecule has not necessarily any motion of progression in any direction, its motions being purely internal. Let such a moving molecule impinge upon another molecule and it will give up a part of its energy of motion to it, and the amount so given up will depend upon the elasticities of the two molecules. If they were both perfectly elastic and of the same mass, the whole energy would be given up; the first would be brought to rest and the second would move in the same direction with the same velocity. Such condition, however, we can never practically have, and a molecule impinging upon another which has a greater mass will receive back a part of the energy it has imparted, and will rebound from the second, and this we call reflected motion for large bodies and echo for molecules. Suppose that a molecule moving under the influence of a sound vibration impinges upon a molecule of iron which is placed in front of the pole of a magnet about which is a coil of wire with its two ends in contact; such forward motion as the iron molecule would receive, would increase the inductive effect of the magnet, and induce a current of electricity in the wire, the energy of this current depending upon the external energy of the moving iron molecule, which depends solely upon its velocity, not upon a distance traversed. This energy finds its algebraic expression in the formula $E = \frac{mv^2}{2}$, and taking the molecule of iron as the unit of mass, the energy of the molecule will at any time equal $\frac{v^2}{2}$. Velocity is simply a *rate*, not a distance, and this is important to bear in mind in this connection. What has so far been applied to a single molecule of air and of iron in the field of a magnet may be applied at once to a stratum of air in the same phase of a sound wave, and a stratum of iron perpendicular to the lines of force of a magnet. Each air molecule will impinge upon its corresponding iron molecule, and the stratum of iron will move toward the magnet in obedience to the impulse; each separate molecule reacting upon the magnet will contribute to the energy of the current, and the entire energy now will be $\frac{Nv^2}{2}$ when N is the number of molecules, or, what is equivalent to it, the mass. In practice we never can have a single stratum of molecules nor anything approaching it. The thinnest film of water we can produce in the soap-bubble must be several molecules in thickness in order to possess tenacity enough to maintain the form of the bubble; but the thin disk of iron that is ordinarily used for a telephone plate must be many thousands or millions of molecules in thickness. It remains then to see how this can modify the foregoing.

The velocity of sound in iron is about sixteen times greater than it is in air, and consequently the sound wave which is one foot in length in air would be about sixteen feet long in iron, while the amplitude of the motion of the molecules would be as much smaller as its relative density is greater, that is, the actual displacement of the molecules must be many times less in iron than in air when the energy of the motion is the same. We may consider the common telephone plate as a thin section of a bar of iron sixteen feet long, and having the same diameter as the plate; then the whole of this section will be in the same phase of the sound wave when it traverses the bar and consequently every molecule in it will be slightly displaced, and, as a mass, it will move to and fro for every wave that traverses the bar. But if the section was 0·01 of an inch thick, there could at no time be more than $\frac{1}{19200}$ of one wave within the section ($16 \times 12 \times 100 = 19{,}200$), and 1,100 such vibrations per second would cause the section to change its phase 21,120,000 per second ($19{,}200 \times 1{,}100 = 21{,}120{,}000$).

In the case of the bar this vibrating section gives up its motion to the section of adjacent molecules, while in the case of the section in the field of a magnet, a part of the energy would be imparted to the air behind it, and a part to the magnet pole in front of it, which would at once be metamorphosed into a current of electricity. When a series of like vibrations is imparted to a body, if the latter be inelastic, the energy of the vibrations is all absorbed by it, and appears as heat; if it be elastic the vibrations will be conducted to every part of it, and the amplitude of vibration will be greater or less as the mass and the form of it vary. If the mass be large, the amplitude of vibration will be simply proportionate to the originating vibration; if it be small, the amplitude will be irregular, and most of the energy will appear as heat by metamorphosis; while, if the form and mass be such that the velocity of the wave in it bears a simple ratio to the wave length, then we have the phenomenon that is called resonance in some cases, and sympathetic vibration in others. For instance, the stem of a vibrating tuning-fork, held upon a large mass like a table, has its vibrations rapidly diffused, and is heard plainer because the large surface in contact with the air is giving off at every point its own motion, and hence the air has a greater amplitude. Let the stem be held upon a small mass like a knife or a pencil, and the latter may be felt to vibrate, but the sound is still weak, and is expended as heat. If the stem be placed upon a tube of proper length, at once the sound is much strengthened, because the length of the tube bears the ratio of ¼, ⅓, or ½ to the wave length. In this case we have resonance or sympathetic vibration.

Now, a small body, whatever may be its form, will receive sound vibrations, and be made to move as a mass more or less synchronous with the original vibrations, of whatever period they may be. The larger the body is, the more the interference from want of synchronism; but in each and every case the movement is simply one of the displacement of molecules, and, in all cases where the body through which a sound wave passes, consists of a series of molecules, as is always the case practically, no two adjacent molecules can be in precisely the same phase of the wave, and therefore, when, as in the case of an iron disk in front of the magnet, the plate is acted on by sound vibrations, each of the molecules will be in its own phase, and will modify the energy of the magnet in its own way; and hence interferences and neutralizations must result, and the greater the number of molecules so acting, the greater will be the loss of energy as represented in the magnetic changes. The plate cannot, theoretically, have a simple pendulous movement, synchronous with the initial vibrations, even for a simple sound, much less for one which consists of the highly complex system of tones which constitute the voice of an individual. In every case of sound propagation there is a mass moving with the velocity of the sound wave, though in the case of simple rectilinear propagation, the mass moving is not the same in any two consecutive instants, and this moving mass is not to be confounded with the molecular movements of its parts, for the absolute space traversed by a molecule is very slight.

It is the energy of this moving mass that is transformed into an electrical current through the mechanism of the magnet and its appropriate coil; hence the very great electromotive force developed. The energy of a vibrating mass is proportional to the square of the velocity, or, what is equivalent to it, the square of the amplitude of vibration; and if we compare two vibrating bodies with each other, both having the same amplitude of motion, and one making twice as many vibrations per second as the other—that is, one an octave above the other—the higher sound will be found to have four times as much energy as the lower one. Furthermore, it has been the common experience that higher sounds are better rendered by a telephone than lower ones, and the overtones in one's voice are not unfrequently much better heard than the fundamental sound, which is in accordance with the simplest dynamical principles.

When the prong of a tuning-fork is struck under ordinary conditions its period of vibration is uniform, and we say that it makes a definite number of vibrations per second. If, however, the prong be brought into the neighborhood of a magnet, and be made to approach and recede from a pole, the rate of vibration must be lowered, for the prong cannot move away from the magnet with the same velocity as it approached it, on account of the increased inductive effect from nearness to the magnet. The fork must then have its pitch lowered. The fork has lost energy, which finds expression by the heating of the magnet in an open circuit and by a current of electricity in a closed circuit. This loss of energy speedily brings the fork to rest; and if the same conditions obtain in a properly mounted induction plate, the loss of energy in this way for a single vibration only prepares the way the better for the reception of the subsequent vibration, of whatever sort it may be, and thus is a real advantage in the transmitter.

Among the transmitters of the *variable resistant* type founded upon the Reiss mechanism of 1861, the sound vibrations simply vary the distance between the surface molecules of the two terminals, of whatever sort they may be, and are at the surfaces substantially what they are within any sounding body—molecules in various phases of a single sound vibration; that is, a greater number of molecules are in contact at one part of the vibration than at another; and as the conductivity varies as the number of surface molecules in contact, we have a complete explanation of the variable current from such devices.

Turning to the receiver, we have an instrument for the convertibility of electricity of variable strength into sound vibrations. Now, the immediate mechanical action of the current is first made manifest in changing the length of the magnet. If this action is sudden and transient, then the longitudinal molecular displacement will be similar to what it would be if the magnet was struck on one pole by any object, and the disturbance will travel to an indefinite distance—a rod or a mile, if the magnet was so long—as a sound vibration, and with the same velocity in the magnet as in an ordinary bar of iron or steel. A series of such pulses occurring within the numerical time limits of audibility will result in sound which may be heard.

Some persons, hearing such sounds from a magnet, have straightway concluded that the molecular movements resulting in sound were not properly sound movements; but a sound vibration is in any case a molecular disturbance that is propagated in a conductor with a velocity which depends upon the elasticity and density of the conductor. It is entirely immaterial whether it originates in this way or that way, by the stroke of a hammer, by the firing of a gun, or by the induction of a current of electricity upon iron.

In the latter case the audibility of the sound would depend upon the amplitude of the molecular displacement in the air, which would in turn depend upon the magnitude of the surface of the body which imparts its own motion to the air, precisely as with a tuning-fork. Hence, if an electro-magnet of any form receives transient electric energy, the click of the magnet may be heard by one holding it at his ear. If the magnet rests *upon* any resonant surface, the click may be heard at some distance; and if the pole of the magnet has an armature of iron upon it, this will act as a resonating surface; so will a piece of wood or a piece of any metal.

If, however, the armature of iron does not quite touch the magnet, but is within inductive reach of it, the armature will be attracted toward the magnet as a mass, and, if it be free to move, it will begin to move toward it. But it is inferred that, because the molecules that make up the disk of a telephone receiver are all of them within the reach of induction, the inductive disturbance among the molecules follows some other law than one of sound vibration. Instead of the disk of iron which has very generally been considered so essential to the efficiency of the speaking telephone, let a piece of iron wire, two or three inches long, be fastened to the middle of a mica, or wood, or paper diaphragm of the ordinary size, mounted in the ordinary way, and let the free end of the wire be brought near to the pole of an electro-magnet, say an ordinary sounder or relay, which is on a closed circuit, with an ordinary carbon transmitter into which one is talking, an ear applied to the aperture of the disk will hear what is said with as much distinctness as with any of the receivers with which we are familiar.

If, also, the ear be applied to the armature of the sounder, there will not be the slightest difficulty in hearing what may be spoken at the transmitter; and if the string of a string-telephone be tied to the armature, and the latter brought down closely to the poles of the magnet, the ear at the opening of the string-telephone will hear with great clearness all spoken words, which shows—in the first instance of the wire and mica diaphragm—that ordinary sound vibrations traverse the wire and give up their energy in the cavity for the ear; and in the second case, with the common armature, that the latter is vibrating, as any small body will do for a tuning-fork—that is, acts as a resonator, while the string-telephone attachment simply transmits the same vibrations to a cavity giving a greater advantage to the ear by concentrating the waves.

There remains one more form of receiver with which some remarkable phenomena, difficult to explain, are connected—I refer to the sounds that are heard from the so-called microphone. When a current of electricity traverses carbon or any other conductor, it is heated, and that heat immediately does work by expanding the conductor. The amount of expansion is proportional to the current. If two molecules of carbon be conceived to be the terminals of an electrical circuit, as soon as they come in contact the current passes and they become heated, and two molecules that are heated and free to move will bound away from each other, and if other molecules free to move are in their neighborhood, they will impart their motion to them and then return together like other elastic bodies; in other words, such heat-motion will instantly be transformed into a sound vibration, and, if repeated sufficiently often, will be heard as a continuous sound.

In each case, therefore, when the observed phenomena are correlated, there is no residuum. There is no need to summon a new form of energy when the old forms are quite competent to effect all the changes.—*Journal of Otology.*

THE TEMPERATURE OF CARBONS GIVING THE ELECTRIC LIGHT.

The temperature of carbons giving the electric light has been examined by M. Rossetti, by means of a thermopile, the face of which is placed at a suitable distance to receive rays from a radiating surface of determinate size; the thermal effect being measured by a sensitive reflecting galvanometer. He comes to the conclusions that—1. The positive pole has higher temperature than the negative. 2. The temperatures vary according to the intensity of the current. 3. They are higher, the smaller the radiating surface, provided it comprises the extreme point. 4. In the negative pole the minimum temperature was 1910° Cent., with a large radiating surface of small brilliancy; the maximum 2532° Cent., the radiating surface being half the preceding. 5. For the positive pole the minimum temperature was 2312°, the carbon being large; the maximum 3200°, with a thin carbon and small radiating surface.

A NEW FORM OF LECLANCHE BATTERY.

A new form of Leclanche battery has been introduced by the inventor, in which the high resistance of the older pattern is diminished, and the employment of a porous pot is dispensed with. The carbon is surrounded with a mixture of 40 parts of pyrolusite, 155 parts of grain carbon, and 5 parts of resin, the latter acting as a cement. This composition is heated to 100° Cent., and subjected to a pressure of 300 atmospheres. It forms a homogeneous cylinder, in the center of which is the carbon electrode. The inventor terms it the "conglomerate mixture" battery. The electromotive force is also higher than in the older form. He has also recently added depolarizing plates, which can be renewed from time to time. They are simply attached by India rubber rings to the carbon.

It appears from careful experiments that the electromotive force of this arrangement is 1·46 of a Daniell element, and the resistance when new 0·718 S. U. The electromotive force, however, diminishes rapidly when the external resistance is low, recovering quickly when the battery is at rest.